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The Physiology of Mandibular Displacement

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Elgin, Illinois

A treatment philosophy which is based entirely upon a single rational step-by-step procedure for any and all patients is sought after and happily assimilated by many practitioners. Such one-track-treatment thought trains have often been observed highballing their way through many chapters in the short history of orthodontics.

The ideal occlusion and the perfect profile are twin-shimmering grails eagerly sought after by patient, parent, and practitioner. We are fortunate that these two goals are compatible with and complementary to each other in the vast majority of our cases. Their successful attainment and preservation are the result of sound diagnosis and treatment therapy. These same goals, in some few of our cases, are unattainable with a purely mechanical approach. These cases are those wherein we find a reluctance on the part of biology to yield to the dictums of physics — whether it be given in units of orthodontic force or degrees of incisor angulation. The practitioner who follows a singular mechanical approach will, in a certain few of his patients, find a wide chasm separating his case from the desired successful completion.

One segment of this subject of difficult cases which is worthy of consideration contains those cases wherein there may exist significant differences in the maxillary-mandibular relation when examined statically on the one hand and dynamically on the other. Practically speaking, they have been referred to as mandibular displacements. It is the intended purpose of this presentation to describe the physiology of mandibular displacement and attempt to focus attention upon the role of displacement in orthodontic diagnosis, treatment and retention.

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The basis of a dynamic analysis of our dental problems is found in muscle physiology, i.e., muscle tonus. The fact that muscle tissue, in vivo, has an active range and a resting length has provided us with a potentially important diagnostic approach.

Sicher and Tandler[1], in 1928, spoke of the rest position of the articulation, the "middle position", and described the role of muscle tonus in producing this position. Niswonger[2] focused attention upon the true vertical dimension of the face and related it to the involuntary rest position of the mandible.

Brodie[3], in his cephalometric study of human cranial growth, noted that the jaws of infants did not occlude prior to the eruption of their teeth and stated: "The evidence points strongly toward a constancy of position of the mandible, which position is maintained by muscle tensions."

Thompson[4] has illustrated the constancy of the rest position. His original hypothesis of stability has been altered to acknowledge the effect of disease, but the basic philosophy of rest position remains sound even under direct electrical studies[5,6] of the muscles themselves and oriented radiographic studies of the temporomandibular articulation.[7,8]

Blume[9], in 1947, studied the path of mandibular closure in Class II, Div. 1 malocclusions. He concluded that the

majority of cases exhibited an upward and forward movement of the mandible to full occlusion. This movement was primarily a rotation as seen at the condyles. A small group of his subjects displayed an upward and backward path of closure from the assessed rest position to occlusion. He found, in these cases, that the condyle was retruded deeper into the articular fossa by a translatory movement.

Boman[10] studied normal occlusion subjects in which eighty-eight per cent of his sample exhibited an upward and forward path of closure from rest to occlusion. Twelve per cent of his group did show an upward and backward movement of the mandibular incisors in moving from rest to occlusion.

Ricketts[11] utilized direct laminagraphic radiographs of the temporomandibular articulation and determined that two-thirds of his sample of Class II, Div. 1 cases before treatment exhibited a downward and forward movement of the condyle from occlusion to rest, i.e., upward and backward path from rest to occlusion.

Ballard[12] has discussed the reflex mechanism producing abnormal paths of closure. Grewcock and Ballard[13] together have illustrated the clinical significance of abnormal paths of closure.

Ricketts[14], in 1955, had shown changes with cephalometric laminagraphy which would cast doubt upon the constancy of the rest position, or perhaps the manner in which it was obtained, in showing pre and post-treatment records of condyle-fossa relation. He proposes a hyperactivity in the protrusive muscles in Class II. Div. 1 cases due to speech, respiratory and masticatory requirements. He feels that this hyperactivity falsely positions the mandibular condyle down and forward in the fossa.

Knowles[15] describes the role of retained deciduous teeth in the production of mandibular displacement.

Thompson[16] has pointed out various directional movements that occur with mandibular displacements.

Fundamentally speaking, to accept the tenet that mandibular displacements exist one must demonstrate: (1) the movement of the mandible from rest to occlusion is along a path other than the accepted normal; (2) the abnormal path of closure is due to tooth interferences; (3) that the abnormal path of closure can be altered and corrected by altering tooth position and finally (4) that an abnormal path of closure can be produced by incorrect tooth movement. The accepted path of closure for the mandible from rest to occlusion in normal occlusion is generally upward and forward. This is based upon the studies of Blume[9], Boman[10], Glowacz[17], Thompson[18], King[19], Posselt[20], and Posselt and Brian[21]. In the anteroposterior direction, the normal bilaterally functioning musculature would bring about a direct mid-sagittal vertical closure without lateral shift.

The deviation of the mandible from a position of rest to full occlusion may be a lateral deflection to the left or right. These cases are generally seen in the deciduous or transitional dentition stages and show evidence of maxillary arch constriction. These patients in closing from rest to occlusion will move directly to the maximal occlusal position without initial tooth contact. Slow volitional closure will result in a tooth contact prior to maximal occlusion which prompts the shift.

Anterior mandibular displacements are often witnessed in the "pseudo" Class III case or in instances of anterior crossbite. The position of certain incisor teeth prompts an anterior shift of the mandible to permit maximal occlusion. Here again the mandibular movement from rest to full occlusion is altered to an excessive upward and

forward path with translation forward and downward of the condyles within the fossae. The presence of a tooth or teeth within the freeway space area initiates a protrusion of the mandible to provide full buccal occlusion. A lateral or posterior shift is impossible because of arch size incoordination and limited fossa area posterior to the condyle; therefore, an anterior shift is the only possible direction to attain maximal occlusal contact.

To the great majority of us lateral and anterior displacements are quite evident. In the lateral displacements, we observe the midline shift from open mouth to full occlusion, the constricted maxillary arch, the over-erupted, lingually placed, deciduous cuspids and the complete buccal occlusion of one mandibular segment. The anterior displacements reveal upright maxillary incisors with attrition of the labial incisal edges, and a marked change from straight profile at rest to concave profile with full occlusion.

Diagnosis in Posterior Displacement Cases

To many practitioners of dentistry, the diagnosis, description and degree of posterior displacement is still a controversial issue. The probability of a full Class II, Div. 1 malocclusion shifting to an ideal Class I occlusion with the orthodontic removal of prematurities is quite remote, but possible. It is rather more common to observe cases displaying lesser degrees of displacement.

Posterior displacement diagnosis and assessment is quite difficult. There are not too many absolute diagnostic features clearly defined. In the instance of anterior or lateral displacements, our prime criterion is tooth-to-tooth relation and their readily apparent shifts from rest to occlusion. The anatomic relations in the anterior of the mouth are quite visible and pronounced as displacement features. The differentiation, however, in Class II, Div. 1 posterior displacement cases is primarily in the assessment of a mandibular rest position, and clinically, the view cannot be from the direct lateral aspect. Prior to the advent of electromyographic technics, the operator had to content himself with obtaining a rest posture of the mandible by various means of phonation, swallowing, or relaxation while studying projected photos selected to relax the individual as well as many other methods intended to produce a minimal of muscular activity in the elevator muscles of the mandible. The reproducibility of the mandibular rest position was often limited by the investigator's approach and ability.

Shpuntoff & Shpuntoff[22] have discussed an electromyographic method of rest position determination. Javois[5] and Mullin[6] have shown that slight electrical activity may occur in the postural muscles of the mandible while it is at rest, but that a reproducible rest position could be obtained by utilizing electromyographic and cephalometric technics. Jarabak[23] points to some electrical activity with rest. Perry[24] et al. have shown the effect of psychic stimulation on the alteration of resting activity in the muscles of the mandible.

To eliminate a lengthy discourse on rest determination, it will suit our purpose at this point to state that speech, phonation and empty swallowing movements seemed best suited electromyographically for producing mandibular movement prior to assessment of a rest position. With confidence and deliberation, a careful operator can obtain a reproducible rest position; it will serve him as a potent diagnostic adjunct in determining the presence or absence of mandibular displacements.

A mandible which moves from the repeatedly assessed rest position to an

occlusal position superior and posterior should well create a suspicion of displacement in the observer's mind. There are also other diagnostic signs which seem to create and/or accompany posterior displacement cases.

One tooth sign that seems to be of importance is the mesiolingually rotated, maxillary first bicuspids. These teeth are often in complete buccal version to the mandibular arch and, in occlusion, seem to hold the mandible distally.

We have already mentioned Knowles' observation on over-retained maxillary deciduous molars. These teeth may be forced into the interocclusal space by the eruption of the second maxillary bicuspids. Their distal marginal ridges contact and wedge against the mesial marginal ridge of the mandibular first permanent molar. This action results in a reflex retraction of the mandible.

Excessive curves of Spee with supraerupted mandibular second molars will produce the same type of retrusion.

At the time of a functional analysis, an excessive bulging of the temporal as it contracts is sometimes indicative of posterior posturing of the mandible. If this is seen, oft times the placing of the operator's little fingers in the patient's ear will result in a definite compression and actual contact between the distally moving condyle and the examiner's little finger.

Many times prior to any orthodontic therapy, our young malocclusion patients will have definite and audible crepitus. This is indicative of abnormal joint function.

Treatment therapy in extraction cases can, and will, often produce displacements. With inadequate anchorage, the molars will tip into the mesial extraction sites. This places tooth material in the freeway space and will result in an attempt by the musculature to spare the teeth and ligaments of the joints from excessive trauma. There will be a posterior shift which will no doubt cause the operator to throw more Class II therapy into the case to overcome the accentuated Class II appearance.

Neurophysiology

Just what then is the true physiology (or pathology) of mandibular displacement? As orthodontists, we concern ourselves primarily with bone, teeth, and their intermediate link — the periodontal ligament. We are headed in the right direction, but we have not pursued the matter to its source.

The mandible moves about the temporomandibular joints by means of muscular contraction which is initiated, graded and restricted by neural impulses arising centrally or peripherally. Those arising centrally are conducted from the large Betz cells located among the top six cell layers of the cerebral cortex. The cells of Betz which are concerned with mandibular movement are restricted to a small area at the lateral of the cerebral cortex on the anterior aspect of the fissure of Rolando. These cells are the primary site for initiation of all voluntary activity. They are the same types of cells that produce shoulder, arm, finger movements; or tongue, lip, and eyelid movements. Those for mandibular movements vary from those for other volitional activity only in the cerebral cortex location and their associational and reflex connections. The cells of Betz and their associated upper motor tracts are not of too much concern to us in the study of mandibular displacement for, as mentioned previously, they are concerned with willed activity.

Our chief concern for the neural background of mandibular displacement is with the reflex level activity. A reflex is an involuntarily produced activity resulting from the stimulation

of a receptor organ, the conduction of an impulse from the receptor organ to an effector organ and the effector organ's response.

The primary components of the reflex arc of a displacement are the receptor organs of the periodontal membrane, the temporomandibular joints and the muscles themselves. The conducting systems are the maxillary and mandibular nerves, their brain stem synapse stations, their connections with the lower levels of the cerebral cortex and/or cerebellum. The effector organs are the muscles attached to the mandible.

Pfaffmann[25] and Stewart[26] have illustrated the presence of certain endings in the periodontal ligament which are sensitive to light pressure. Corbin and Harrison[27], as well as Szentgothai[28], have demonstrated the pathways which the impulses travel from the periodontal ligaments and muscles to the brain stem. These nerve endings (receptors) in the periodontal membrane are classified as proprioceptive. Proprioceptive receptor organs with similar pathways and functions are also found in the muscles of mastication as well as the temporomandibular joints.

Proprioceptive endings are primarily concerned with muscle and joint sense. They are chiefly encapsulated sensory endings and in the basic modality of proprioception are concerned only with connections to and from the subcortical levels. However, in association and integration with other sensations centrally, they may provide information to the cortices for higher synthesis.

Lateral Displacement

The typical lateral displacement is primarily a functional malocclusion. If the unequal and unilaterally synchronous muscle pattern is perpetuated without orthodontic correction, it is conceivable that the functional malocclusion may produce a structural malocclusion as well.

The neuromuscular activity responsible for a unilateral mandibular shift is bilateral in nature. Previous electromyographic investigations have corroborated the anatomists' contention that the temporal muscle is primarily a postural or positioning muscle. In mandibular displacement, the temporal muscles again show their positioning function.

The movement of the mandible through the freeway space is usually conducted by a bilaterally equal and synergistic contraction of the mandibular elevators. In the empty swallowing movements, in the mastication of a soft bolus and in certain speech movements the primary action is that of the temporals. In forced swallowing and mastication of a moderate or a heavy bolus, the masseters and internal pterygoids may enter in.

If tooth material is interposed within the vertical of the freeway space in such a manner as to prevent maximal occlusal contact, the mandible will be shifted by the musculature to a position of maximal contact which may vary from its median occlusal position. This movement to a displaced or eccentric position is the result of neuromuscular accommodation.

The basis for this eccentric movement is as follows: As the mandible moves from its rest position along a symmetrical path of closure produced by a balanced and coordinated musculature, a tooth prematurity is struck. The contact pressure of mandibular tooth against maxillary tooth stimulates the periodontal endings about the teeth which contact. An impulse is initiated which is propagated along the maxillary and mandibular sensory nerve roots to the mesencephalic level of the brain stem. A pattern of neuromuscular contraction is dominant which, with ease and efficiency, is best accommodated for maximal occlusal contact.

If the displacement is the result of a unilateral impingement of the freeway space, the musculature will contract with greater amplitude on one side to shift the mandibular teeth away from the prematurity to an occlusion that is more efficient. This could conceivably result in an anterior, lateral or posterior unilateral displacement. The greater majority are lateral with some degree of posterior displacement on the side of the prematurity and some anterior displacement on the side contralateral to the prematurity.

When we observe an anterior midline interference, we may have an anterior or a posterior displacement. An anterior displacement is usually associated with relatively upright maxillary incisors and an acceptable maxillary occlusal plane curve. In these instances the midline nature of the premature contact initiates a bilateral masseter and temporal contraction (probably also internal and external pterygoid contraction) which protrudes the mandible anteriorly to a position of efficient maximal contact.

If the maxillary incisors have an extreme lingual inclination and the level of the incisor occlusal plane is at a different vertical than the maxillary buccal segment, a distal displacement may result. These are the Class II, Div. 2 cases. In these instances the posturing effect of the temporal muscles retracts the mandible from the premature contacts and provides a maximal occlusion distally.

The distal displacement is difficult to assess in diagnosis and, to the neophyte, often is not fully recognized as a displacement until treatment is undertaken or completed.

The temporomandibular joints have a degree of freedom which is important in masticatory function. This degree of movement is often utilized through necessity to accommodate tooth contact positions. The teeth with their proprioceptive system have the capacity to affect jaw posture during occlusion. The posture of the jaw is controlled to a certain degree by the joint and muscle proprioceptors, but these are primarily active in nonoccluding jaw positions. If, in closure from a position of nonocclusion to occlusion, certain stimuli arise which signal improper balance or incorrect posture of the mandible, the musculature will search for a position of occlusion that will bring the greatest harmony and protection to the teeth, their supporting structures and the joints. In time, such a pattern of neuromuscular activity may well establish a habit (learned) position within the neuromuscular circuit which will circumvent the initial contact and will provide for a direct closure to the maximal occlusal position.

The normal and usual path of closure from rest to occlusion is an interextreme position (Posselt)[20] and is the result of a monosynaptic reflex (Szentgothai).[28] This closure pattern is present before the eruption of the teeth and develops with sucking and swallowing. The advent of the teeth and their eruption provides a possible reinforcement of this reflex or will necessitate an alteration of it. In those cases of reinforcement, the occlusal position is upon the arc of the innate monosynaptic jaw reflex. If the two do not coincide, then occlusal posture is altered to provide the maximum of efficiency and the minimum of trauma. In these cases the alteration of the usual jaw closure path is through unequal muscle response about the individual joints to provide a maximal occlusal position. The innate pattern is still present, but it is overruled by homostatic adjustment.

A very simple description of the physiology of the rest position and the physiology of a normal closure should assist us in our understanding of mandibular displacement problems.

The resting posture of the mandible is maintained by the tonic contraction of certain special fibers within the muscle bulk of the elevators of the mandible. These fibers are called intrafusal fibers in contradistinction to the regular muscle fibers which are extrafusal fibers. The intrafusal fibers are part of a very special sense organ found in voluntary muscle. These organs for stretch response were discovered over one hundred years ago by Hassal.[28] Ruffini[29] described them by stating: "Apart from the organs of special sense (ear, eye, etc.,) the body possesses no terminal organ that can compare with these in richness of nerve fibers and nerve endings."

Sherrington studied these special endings over a period of forty years and ultimately developed his theories of muscle reflex from the activity and responses of the muscle spindles.

The muscle spindles are found parallel to the regular muscle fibers. The intrafusal muscle spindles have a rather complex sensory system which receives signals regarding the state of tension within the muscle. The muscle spindles also possess a motor innervation which produces contraction of their intrafusal fibers upon proper stimulation.

With a parallelism existing between the regular muscle fibers and the muscle spindle fibers, shortening of the regular muscle fibers takes tension off the intrafusal fibers and they relax. If the muscle is stretched, these special sense organs are also stretched and they reflexly contract to prevent further straining of the muscle or to grade the speed and response of the extrafusal fibers' stretch. We have in the muscle spindle a very precise tension recording organ; not only will the sensory component of the spindle record tension, but also, if the tension in the muscle due to stretch increases too rapidly or to too great an extent, the muscle spindle will contract in an attempt to alter the new posture of the muscle and return it to its resting length.

A second and very important sensory organ associated with voluntary muscle is the Golgi tendon organ. This sensory ending is found in the tendon of muscle and it is in series to the muscle fibers. Therefore, with any change in length, either shortening or lengthening, these sensory organs signal the change to the central nervous system which then grades the contraction or stretch of the muscle through reciprocal innervation or co-contraction.

The most important function of both of these systems, one in parallel to the muscle fibers and the other in series to them, is to immediately signal any change in muscle length and attempt to return the muscle to its genetically ordained and functionally determined rest position.

Thus the healthy rest position of the mandible provides us with a physiologically ideal starting position or reference point for ascertaining the complexities of our orthodontic cases from the functional view point.

Empty swallowing movements of the mandible differ from masticatory movements in many ways — the principle one being the equality and synergy of the empty movements in contradistinction to the bilateral muscle contraction but unilateral dominance of the masticatory act. In many of our displacement cases the patient unconsciously selects his food to maintain a diet of soft, easily triturated boli. This is a direct result of the loss of power from the masseter-internal pterygoid complex in mastication and may be brought out in questioning the parent. These muscles do not display their true contractile power, but are reflexly inhibited by prematurities in the freeway space. The difficulty of mastication is directly proportional to

the severity of the displacement. The temporal muscles dominate in the dual function of closure and posturing the mandible to the most efficient maximal contact occlusion.

A posterior displacement of the mandible is initiated by proprioceptive impulses from premature tooth contact early in the eruption of the offending teeth. The impulse is transmitted to the mesencephalic nucleus of the brain stem and from thence to the motor nucleus of the trigeminal nerve. The signal from this point is centrifugal and is carried in the efferent nerves to the muscles of the mandible to affect a change in functional posture to a position of accommodation and efficiency. The adaptability of the neuromuscular system and the temporomandibular joints is greater than that of individual teeth in prematurity. The origin of the displacing reflex may occur at any period of occlusal development.

Its genesis is slow, but as unyielding as the eruption of the teeth. In time, a path of closure which circumvents the initial contact is developed through the muscle and joint proprioceptive systems.

The temporal muscles do a greater portion of the work of mandibular movement than the masseters particularly in swallowing, mastication and other acts which necessitate tooth contact or occlusion. The nonoccluding empty movements of the mandible do not call forth the necessity of the displacement and a more harmonious and balanced synergy of muscle activity results. The mandible moves in and about its rest position freely and, if the patient is requested to slowly and volitionally close, the prematurity producing the displacement is often struck.

Posselt,[20] Sicher,[30] and Donovan[7] have shown that the mandible of ideal occlusion individuals can often be retruded up to 1 mm from the position of maximal tooth contact. This range of movement is not found in all patients, but Lammie[31] et al. have speculated as to the possible basis for its existence. They feel that maximal power in masticatory strokes comes only when the mandible is distal to this maximal occlusal position. The closure into centric occlusion from this terminal position calls forth the support of the external pterygoid, internal pterygoid, masseter and temporal. This is a position of a power stroke and not a static condyle fossa relation.

It is possible that this slight space distal to the condyle is utilized in the repositioning of the mandible in the posterior displacement cases. It is certain that power in Class II, Div. 1 malocclusion, when biting in centric, is lacking and even more so in mandibular displacement patients.

The response of posterior displacement cases to treatment is quite variable. In certain instances the mandible will be repositioned forward by the musculature as soon as the reflex initiating teeth are moved to proper occlusion. In other cases there is only a barely perceptible repositioning anteriorly. In these latter cases we routinely institute the mechanical procedures indicated for the correction of the malocclusion.

It has been observed that, in the attempt to correct Class II, Div. 1 displacement cases with extraoral therapy, we may complicate our problem by tipping our maxillary first molars into a greater interference pattern with the mandibular teeth. This initiates more retraction of the mandible. We see our maxillary teeth move slightly distal, but their relation to the mandible remains unchanged as the latter is further retruded.

Oft times in our extraction cases, inadequate anchorage preparation will permit the tipping of teeth about the extraction site. This may bring certain

cusps into the freeway space and result in an orthodontically created displacement. Here again we see our anatomical relations become more severe or remain unchanged as treatment supposedly progresses.

One final potential problem relating to displacements may not occur until several years after treatment. Reference here is made to those cases wherein we have finished the occlusion to an anatomical ideal with minimal overjet and overbite. The retainer is left in place and periodic retention visits with static checks of the occlusion indicate all is well. However, time and growth are against us and, in time, the patient complains of sensitive incisors, sore temporomandibular joints, and painful masticatory muscles. These are the cases wherein we have had some latent mandibular growth. The maxillary incisors have been unable to tip labially because of the retainer which is worn at night and the musculature has displaced the mandible distally or laterally to avoid trauma to the teeth. This adjustment was satisfactory for a time, but growth finally succeeded in passing accommodation and then the teeth were traumatized. The muscles attempted to retract to a greater extent resulting in muscle fatigue and spasm. The joints were made sensitive to the strain on the ligaments created by the muscle retraction initiated by the tooth contact.

Summary

A neuromuscular basis exists for a response to premature tooth contact. These premature contacts may occur as the result of early finger and thumb habits, aberrant eruption of permanent teeth associated with overretained deciduous teeth, rotations of certain permanent teeth, tipping of teeth about an extraction site, faulty restorative dentistry and improper orthodontic control of tooth movement. The prematurities created by these and other oral factors prompts a repositioning of the mandible away from the high tooth, or teeth, to an occlusal position of maximal contact. This mandibular shift is detected only by a discerning orthodontist utilizing a dynamic diagnosis. The early correction of the functional problems will permit a more clear evaluation of the structural problems of his orthodontic case.

Conclusions

(1) Mandibular displacements do exist and their direction of displacement is the result of anatomic relations (static) and neuromuscular response (dynamic).

(2) The degree of displacement is difficult to assess longitudinally on a patient because of the influence and effect of growth.

(3) A recognition of occlusal dynamics should not be left until after the orthodontic correction is completed, but rather the dynamics of occlusion should be considered throughout the entire treatment and retention period.

Any professional science as exact and demanding as ours, of necessity, must have basic guiding concepts. Ours is acknowledged to be deeply steeped in mechanics and that which has preceded is not intended as a critique of this mechanical background of orthodontics, but rather as a caution, lest we forget the principal purpose for, which the teeth have been moved, and that is or should be — improved function.

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Discussion

Dr. John R. Thompson

These are both excellent papers. The first, Dr. Perry's, is based on research done at a university and Dr. McIver's* is the result of investigations carried out in an orthodontic office without the oft spoken advantages of university facilities. Dr. McIver has demonstrated that competent research can be mixed with a busy orthodontic practice. Actually there are some advantages to office research in that there is better control of the study material and continued availability of the subjects for reevaluation. I hope that Dr. McIver will continue to observe and to make records on these patients so that the cross-sectional studies will be enlarged to become serial and hence increase in value. Conditions that exist in a twelve year old may be different at fifteen.

I do not understand many of the anatomical terms used by Dr. Perry but I do know that this approach to occlusion of the teeth is important. It represents a transition from the mechanical to physiological. It is a step in the direction of thinking of teeth, not only from the point of view of esthetics as they appear on models, but also how they function. A malocclusion is classified as such since it deviates from the ideal anatomical occlusion but it may function quite efficiently, hence, it is a good physiological occlusion. After orthodontic treatment a fine anatomical or ideal occlusion may have been attained but function may not be as good as it was previously, thus it is a poor physiological occlusion. Our thinking must be expanded to evaluate the occlusion in its functional relation to the temporomandibular joints and the musculature of the head and neck. Dr. Perry has made it quite clear that this mouth of ours is not an articulator. It is alive — it is responsive to normal and abnormal stimuli. The position and movements of the mandible are controlled by stimuli recorded in the nerves of the periodontal membrane, joints and muscles. Changes in the occlusion alter the position of the mandible neuromuscularly as well as mechanically.

There are many splendidly treated cases being exhibited in the other room. A high degree of success has been attained in many in so far as interdigitation of teeth is concerned, but there are indications in some that the occlusion may not be in harmony with the temporomandibular joints and musculature. This is not a criticism. I cannot place myself in the position of a critic as I have experienced all of the unpleasant experiences associated with orthodontics as have you, but it points to the complexity of our task as orthodontists and we must not be content with our current way of thinking.

You who are listening may very sincerely say, "I haven't been bothered with clicking joints or muscular problems". If this is your opinion, then ask yourself whether or not you really have a basis for this statement. Possibly you have not looked; you may not have palpated the joints; you may not have placed your fingers in the ears to note crepitus; you may not have felt the teeth and listened as your patients have occluded their teeth repeatedly; you may not have observed the muscles on one side contracting before their fellows as occlusion is attained unevenly. You do not need a cephalometer or electromyograph but what you do need is the patient and the basic understanding of the structures involved, along with the motivation and desire to apply a functional analysis. This must become routine procedure in all orthodontic practices.

*Dr. McIver's paper was published in the October, 1959 issue.

We need not be frightened by Dr. Perry's remarks to think that we must now delve deeply into the complicated subjects of neuroanatomy and neurophysiology, but we do need to be aware of their implications as taught to us by those clinicians who have studied them in detail. Someday these subjects will be important in the dental curriculum along with clinical application of applied anatomy and physiology of the stomatognathic system — every bit as important as the technical subjects of dentistry and orthodontics.

Dr. McIver has been very fair in his appraisal of a complex subject — the position of the mandible. He has not entered this investigation with the objective of proving something. If we look hard enough, we can always find what we wish to find. The problem has posed a challenge to him and he decided to investigate it.

Dr. McIver has stated that the rest position is unreliable in an analysis, particularly of forward mandibular displacement or the "protrusive bite". This is quite true but the evidence offered to support this contention represents a variation in the rest position. Under abnormal muscular conditions the correct rest position cannot be shown but, when normal conditions are established and the symptoms of pain and strain are eliminated from the musculature and joints, the correct rest position is possible. This variation is seen frequently in complete denture cases. It represents a pathological variation in rest position and is not evidence as to the unreliability of the concept.

Likewise it is pointed out that the retruded position is not always reliable. At this time it is well to say that neither the musculature nor the joints are reliable guides to mandibular-maxillary relation under abnormal conditions. Both are quite dependable under normal conditions.

The rest position of the mandible is still important even though it is agreed that it is not an exact method of analysis, but is there any exact and positive method of analysis in use today? No—not now or ever. There is no such thing, and after one gathers the desired case records, the final analysis will be the interpretation of the individual mind.

Dr. McIver mentioned that many individuals with excellent functioning dentitions have a retrusive range. That is in accord with our observations and also those of Posselt and Beyron whom he has quoted. In his excellent group studies McIver states that, "eighty per cent of adults can retrude slightly beyond the intercuspal position". Also he observed that "seventy-three per cent of the Class II malocclusions could not retrude beyond intercuspal position while seventy-six per cent of Class I cases could not retrude". One might interpret this to mean that some of the malocclusions were in an abnormally retruded occlusal position and thus, a retrusion was not possible.

His further investigations of ten persons with excellent dentitions who could not retrude and ten others who could retrude point out that there is normal variation in function as well as in morphology. People insist on being different from one another. It is important to note that in both groups, while the posterior structures of the articular fossae may vary, the anterior relations of the condyles to the eminentiae articularis, the functioning areas of the joint, are identical.

Our objective in treatment of a Class II, as Dr. McIver has emphasized, is to establish an occlusion at or near the most retruded position. Whether or not there is some retrusive movement from the maximum occlusal position is not important as long as joint function is normal and the mandible is not deviated by the dentition into an abnormal occlusal position. Whether we can achieve this in seventy per cent of our

patients is not established and such group figures or statistics are not as important as checking each individual patient as to his function. It is of little good to have an individual occluding at his most retruded position if his temporomandibular joints click and snap. This is just as serious or more so than the individual who is deflected into a slight forward position to attain occlusion.

I believe that we do have to fear introducing an abnormal retrusive position in many of our cases. In the treatment of protruding maxillary incisors, they are retruded to reduce the overjet. I have on occasion moved these teeth too far to the lingual at too early an age and have caused a mandibular retrusion and clicking of the temporomandibular joints. In treatment of a malocclusion a good anatomical occlusion may be established at say the age of fifteen and this occlusion may be in harmony with normal joint function. But should mandibular growth proceed at a more rapid rate than maxillary and in a more horizontal direction, a traumatic incisal relation would be created. This would, as Dr. Perry has explained, stimulate a mandibular retrusion. Actually, individuals can grow into retrusion or posterior mandibular displacement long after treatment has been completed.

Dr. McIver has outlined his treatment procedures quite adequately. With these I have no quarrel and I would be pleased for my children to receive his treatment.

Dr. Alton W. Moore

I enjoyed these papers very much and commend the authors for their efforts. In my discussion I will attempt to consider them as a unit rather than separately in that their subject matter is interrelated.

The first thing I would like to point out are some facts that were brought out by these essayists. Dr. Perry pointed out that the mandible at rest position may translate backward and upward when the mandible moves into full occlusion. On the other hand Dr. McIver states that after the teeth have arrived in full occlusion, the mandible may be translated even farther distally into a more retrusive position.

These three positions, rest, occlusion and the most posterior position that the mandible may assume in the glenoid fossa are recognized facts. It has been reported many times in a group of patients with Class II malocclusion that recording the rest position and occlusal position of the dentures cephalometrically will show that some patients exhibit a translation of the condylar head posteriorly from rest position to full occlusion. Other patients, and sometimes the same patients, will exhibit the ability to translate the mandible even farther back from its full occlusal position through mechanical stimulation.

These are facts that have been observed and reported many times in the past. We cannot dispute these observations, however, there is no accord whatsoever in the interpretation of what these facts might mean clinically to the orthodontist. Several questions may be raised that complicate the making of a correct clinical interpretation of the significance of these observations. Some of these questions are posed here for your consideration.

What effect does growth have on these condylar relationships as an individual grows over a period of time? As yet this question remains unanswered because there has not been a sufficient number of studies of different age groups or serial studies of the same children to show what effect growth itself may have on condylar position.

Another question that may be raised is the effect that age may have on condylar position. Is the evidence of condylar translation as important in a

thirteen-year old child as it is in the adult? Or is the reverse true? We have all recognized temporomandibular joint symptoms in the form of pain and muscle spasms in the adult. I personally have not observed them in my own patients, who are of a younger age group, but this may be due to the fact that I have not been looking for these symptoms as was previously pointed out by Doctor Thompson.

Another question, is there a relationship between these mandibular positions that can be recorded and the symptoms that we have presented to us by our patients? Can a certain amount of condylar translation be considered normal? We know that there is a range of normal variation in the interrelationship of other parts of the body, so isn't it logical to assume that such may be true for the temporomandibular joint? However, the question of how much translation is within the normal range is yet to be answered.

Another limitation that is placed upon our correctly interpreting the clinical significance of condylar translation is the fact that we record these positions in two dimensions when we are dealing with a three-dimensional subject. We also record only one temporomandibular joint at a time and I am not aware of any studies where an attempt was made to correlate the records of the temporomandibular joint relationship on both sides of the patient.

Electromyography research has produced graphic recordings that illustrate muscle activity. These recordings are real and in many instances are reproducible on the same individual as well as different individuals. The clinical significance of these recordings is, however, open to multiple interpretations. A hypothesis may be formed as to how these records correlate with the clinical picture. The hypothesis must be tested clinically and correlated with other methods of measuring before a sound concept can be constructed. Until this is done we are still dealing with various viewpoints that may or may not have clinical significance.

My own observations and reading have led me to believe that we have observed many facts and have developed several hypotheses, but we have not as yet reached the stage of a positive working concept. The interpretation of the transitory positions of the mandibular condyle may differ one person to another. We may feel that the correct position is the most posterior retruded position and that anything forward of this is an anterior displacement, or we may interpret that the anterior position is correct and anything posterior to this is a distal displacement of the mandible. As yet we are still in a position of attempting to correlate our clinical results and observations with the records we obtain from our various measuring devices.

It has been observed that some patients exhibit a forward rest position and the condyles translate upward and backward as the mandible is moved into full occlusion. However, following orthodontic treatment it is later observed that the rest position and the full occlusion position of the condyle are the same. What occurred? Did the rest condylar position move back to the former occlusal position or did the occlusal position of the condyle come forward and become synonymous with the rest position? Frankly, I don't know the answer to this question but I do know that when I have observed this occurring in some of my patients that the mandible cannot be retruded any more by forceful means. Some may interpret this as evidence that the occlusal position of the condyle is the correct one; however, we cannot prove this because the effect of growth in the temporomandibular joint region makes exact interpretation impossible. Further

study will have to be executed before we can be dogmatic in regard to our interpretations.

Perry's electromyographical studies are an attempt to explain temporomandibular joint function on a physiological basis. Much is known about the growth and microscopic anatomical features of the temporomandibular joint and controlling musculature. Correlating this information into the total physiological picture of the function of the mandible should be relegated to interpretation at this stage of our knowledge. Such studies should not be disregarded because we are not able at present to apply the findings in our clinical practice. In the future as we gather more information these observations will help round out the complete picture.

At the present time I find myself at a loss when I attempt to analyze the significance of the rest position of the mandible to the clinical analysis of my patients. Twelve years ago when I first went to the University of Washington I was not in such a quandary. I told my students that we had true Class II malocclusions, as well as false Class II malocclusions which exhibited Class I molar relationship at rest position. After a few years of observing our clinical results, a study was conducted in which condylar translation was not found in most of the treated Class II malocclusions. In those individuals where translation still existed between rest position and full occlusion, a dual bite was present. These cases we felt were unsuccessfully treated. This, of course, is a matter of interpretation. In my experience, very few patients who exhibit a Class II malocclusion at the start of treatment correct their molar relationship in a short period of time. I was going to say that I have never had one exhibit this phenomenon, however, recently such a case presented itself in my own practice. Within a few weeks time this patient changed from a Class II molar relationship to a Class I. I found it impossible to forcibly move his mandible distally even when he was completely relaxed. The answer as to what occurred in this particular patient is unknown to me. It is only through such studies that have been discussed today that we will find the answer. We are increasing our number of known facts and I hope that sometime in the very near future we will have enough information to evolve a concept that will be clinically workable in the analysis and treatment of our patients.

At the present time I am personally analyzing all of my Class II malocclusions with the mandible in its most retruded position. I find that from a standpoint of recognizing the severity of the problem facing me that this seems to be the most realistic approach. I have more or less given up the rest position of the mandible in the analysis of malocclusion when I am evaluating the severity of the problem or the eventual prognosis of treatment.

In closing I would like to take one exception to a statement made by Dr. McIver in his paper which is as follows: "It is my belief that most Class II non-extraction cases need not be started before the late mixed dentition period when there are perhaps two or more deciduous teeth remaining. Early mixed dentition treatment with bite plane and headgear is all right if there is no objection to four or five years of care, but most of these cases require full appliance if satisfactory results are to be achieved."

I take exception to this statement because I feel that the reverse is true. The material presented by Dr. King in his analysis of mixed dentition treatment is additional evidence supporting the early treatment point of view. The advantage of treating children during their active growth periods, I feel, is well established and I personally have

no objection to treating my patients for a four or five year period if it becomes necessary. In fact, I have several patients who have been under treatment with headcap therapy for six and seven years and I am proud of the results achieved. I feel that the results achieved in these cases have produced the best physiologic occlusion, the best harmony and the best balance of all of the associated structures that was possible for the individual. The length of treatment doesn't concern me especially when it can be accomplished more simply with less time expended upon my part even though treatment has extended over a longer period of time. I feel that the child has benefited more from such treatment and I have not had any trouble with cooperation from these patients.

In my opinion the length of time that an appliance must be worn should not be used as a criterion of what type of treatment procedure should be utilized. We are dealing with growing children, some growing much slower than others, others growing more rapidly. The ones growing rapidly are going to respond more rapidly to treatment. Those growing slower will likewise have a slower response to treatment. Granted we can "horse" teeth around in a short period of time; but is this going to give the best balanced and stable denture for the individual throughout his lifetime? I seriously doubt that treatment time should be a factor as to what treatment procedure might be used.

In closing, I would like to again thank the essayists for their presentations. They have made a very important contribution to the overall problem. I agree with the facts that have been reported but I do not necessarily agree with the interpretations that have been made concerning their clinical significance. I respect the opinions of others, but I will not necessarily agree with them until they have been scientifically nailed down and their usefulness clinically proven.

Dr. C. C. Steiner

In the beginning, I was alarmed when I found myself faced with the prospects of discussing a paper titled "Physiology of Mandibular Displacement", by Dr. Perry, a teacher in the School of Dentistry, Northwestern University, and in participating in a panel discussion of that paper with the professors of two orthodontic departments of leading dental schools. I am sure that you expect of me, a strictly clinical orthodontist, a discussion of the clinical aspects of the subject of mandibular displacements.

First, let me say that Dr. Perry's paper is beautifully written, it was nicely presented and it reflects careful and expert assessment of a wealth of research material. If I understand a number of the statements in his paper, we do have some differences of opinion regarding a few of these beliefs. I do not feel, for instance, that the rest position is necessarily constant over a lifetime and I do not believe that it is a logical base from which to judge mandibular displacements. More specifically, if the mandible does close upward and *backward* from the rest position instead of upward and *forward*, which is usually regarded as being normal for it to accomplish maximum occlusion closure, I do not believe that this action necessarily implies mandibular displacement of the mandible in this position of closure.

I agree with him that mandibular displacements do occur and that generally they are the results of dental prematurities which may and very often do exist in all classes of malocclusions and in connection with other pathological conditions.

Dr. Perry said, "One segment of this subject of difficult cases which is worthy of consideration contains those cases wherein there may exist a significant difference in the maxillary-mandibular relations when examined statically on the one hand and dynamically on the other."

He also said, "Thompson has illustrated the constancy of the rest position. His original hypothesis of stability has been altered to acknowledge the effect of disease".

Dr. Thompson's discussion this morning makes it certain that he believes as I do, that the rest position can be altered by changing its environment. I accept, as he does, that the rest position is a constant under constant conditions.

Quoting Dr. Perry again, "The basic philosophy of rest position remains sound even under direct electrical studies of the muscles themselves and the radiographic studies of the temporomandibular joint in articulation."

To establish the normal path of closure from rest to occlusion, Dr. Perry quotes Boman as follows, "Boman studied normal occlusions in which eighty-eight percent of the sample closed upward and *forward* from rest position".

Dr. Perry states, "Ricketts utilizing direct laminagraphic x-rays showing the temporomandibular joints determined that two-thirds of his sample of Class II, Div. I cases before treatment exhibited a forward and downward movement of the condyles from occlusion to rest". (This would be an upward and *backward* movement from rest position to occlusion.)

Using the cephalometric methods that I have suggested, we have found that two-thirds or more of our Class II, Div. 1 cases close upward and *backward* from rest positions to maximum occlusion. This differs from the findings of Dr. Boman when he surveyed the closure of cases with normal occlusions.

Dr. Perry clearly states, "Fundamentally speaking, to accept the tenet that mandibular displacements exist, we must demonstrate that movement from rest to occlusion is along a path other than the accepted normal".

I must infer, therefore, that he would regard the majority of the Class II, Division I cases and/or those that close from rest position to occlusion in an upward and *backward* direction as being mandibular displacements.

I regard a mandible as being displaced if it is functioning or is closed in a manner or in such position that causes the condyles to be out of harmony with the other parts of the temporomandibular joint. I believe that it is possible for a mandible to be distally displaced but that such displacements are rare and small in extent. I also believe that if abnormal conditions which bear upon the positioning of the mandible are normalized, then the normal positioning of the mandible will usually occur.

I accept that the rest position is a reality for each case and that it is a part of the general functioning activity of the denture as it exists at the time. I also believe that it changes as the conditions which dictate the functioning of the denture are changed.

As evidence that the rest positions of Class II, Division I cases are generally different from those of normal occlusion cases and that they practically always change when the Class II malocclusions are successfully treated, I offer the following cases in evidence. (slides showing the before and after treatment records of four Class II, Div. I cases were shown and explained).

I congratulate Dr. Perry on this excellent paper and I appreciate this opportunity to comment upon it.

Dr. H. T. Perry

Dr. Steiner has suggested that many of these differences of opinion could be ironed out if we were closeted together for a few hours in a room. Now he is a Dutchman and I am Scotch-Irish, and it is difficult to speculate what would happen in such a closed conference.

T. S. Eliot has said:

"Between the conception
And the Creation,
Between the emotion
And the response,
Falls the shadow."

Everything that has been said yesterday and today acts to illuminate the shadow and darkness which so often envelops us because of misunderstanding and semantics.

Displacements are a very controversial issue and we have all acknowledged their existence; however, we disagree on their incidence. I believe if we are to "boil it down", it comes back to the original tenet of what is the rest position.

Dr. Steiner has said, "I do not believe that the rest position is necessarily a constant over a lifetime, and I do not believe that it is a logical base from which to judge mandibular displacements."

In the first instance, I do not believe that rest position is inviolate or invariable within the individual — it will vary with disease, pain, fatigue and occlusal alterations in either the vertical or horizontal plane. The rest position, however, does have a sound physiological basis in the healthy individual as mentioned in the paper discussed by Dr. Steiner. In the second instance, occlusion with the muscles contracted is not a logical base from which to judge mandibular displacements because the mandible, in occlusion, is already at its terminal position. It must be emphatically stated that a properly assessed, healthy rest position is a more tenable base from which to judge displacements than the occlusal position. The reasoning behind this statement is that the tooth contact initiating the displacement prompts unilateral or bilateral muscular response to position the mandible to a maximal occlusal position. This latter position may be eccentric to the accepted, or habitual, path of closure and thus prompt inequal or imbalanced muscle contraction to obtain it. The musculature of the mandible at rest, in the healthy rested individual, is not directed by proprioceptive or tactile stimuli from the periodontal membrane and thus, without joint or neuromuscular disturbance, is most likely to be bilaterally balanced and sagittally centered.

Dr. Steiner states that he does not believe an upward and backward path of closure is abnormal. It is acknowledged that variation reigns supreme within and between individuals. Some individuals may have an upward and backward path of closure which is not abnormal, but from the research data and studies previously mentioned, we should not accept it as normal until we have proven first that it is not abnormal.

Dr. Steiner again states that two-thirds or more of his Class II, Div. 1 cases close upward and backward from rest to occlusion and from this he infers that I would say they are all mandibular displacements. Here it is wise to point out that the position of rest and the assessment of this position are all important to this discussion. An improperly or hastily determined rest position would result in an unacceptable or abnormal path of closure.

Dr. Steiner believes the same as I when he states, "------ if abnormal conditions which bear upon the position

of the mandible are normalized, then the normal position of the mandible will usually occur." But what is normal? It is that centric mandibular position which is attained and maintained by equal bilateral contraction of the mandibular elevators with maximal harmonious and simultaneous tooth contact, which results in minimal strain to the temporomandibular ligaments, capsule and disc. It is not a position attained and maintained by inequal muscle tension due to tooth prematurities.

There seems to be quite a divergence of opinion between those from the Western and Eastern slopes of the Rockies as to how the mandible behaves. I believe on the Western slope, and I say this in jest, you get more sunshine and rain, and thus nature grows things a lot faster out there. On the Eastern slope, we get much less rain and have to rely upon fertilizer.

Thomas Carlisle once said that "the moment that we become angry in controversy we cease striving for truth and we strive for self." I believe what has been said here this morning has certainly opened my eyes to other possibilities and avenues of thought. I want to thank the discussors for being as kind and as lenient with me as they have been. Finally, Dr. Steiner, you stated in your opening statement that you were "strictly a clinical orthodontist". There are none of us here who are any other than clinical orthodontists for that is the nature of our breed. There may, however, be some of us who have never been "graduated" and still cling, like the ivy, to the university walls, for we recognize orthodontics as a clinical science with a necessarily heavy, basic science foundation.

The Relationship Between Tooth Formation and Other Maturational Factors

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The formation and eruption of the teeth in and through the jaws is a subject of importance to orthodontists as well as to workers in allied fields. Since x-rays have been used for over fifty years, one might expect tooth formation to have been studied more extensively than it has been during this time.

The material for our studies consists of a group of healthy, white, Ohio-born children, primarily of the middle socioeconomic class and enrolled in the longitudinal studies of growth and development at the Fels Research Institute, Yellow Springs, Ohio.

From this group we have been able to obtain serial oblique jaw radiographs of two hundred and fifty-five children and a tremendous amount of information on somatic and sexual growth and development, on biochemical functioning, on behavior, personality and on health and disease. Some of these data are now being viewed in connection with the material on tooth formation in an effort to determine the various endogenous and exogenous factors that affect the tempo of dental development, patterning differences, and the extent of sexual dimorphism. Since the oblique jaw x-ray is the source of our data, our observations are confined to the mandibular posterior teeth.

We have endeavored to set up various stages of tooth calcification and tooth movement, to learn the sequence of such events, to determine sex differences in, and variations of, tooth formation and finally, the degree to which dental maturation relates to general growth and development.

The data analyses reported here have been made possible by a research grant M 12-60, U.S.P.H.

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STAGES

It is obvious that many stages of tooth formation could be used. Various workers have estimated the proportions of crown and root formation by the quarters; others have utilized as many as twenty stages for a tooth. We have chosen, to date, to adhere to a relatively simple system of stages. These stages are: 1) beginning calcification of the crown, 2) completion of crown formation and 3) apical closure (Fig. 1). In addition to the above, we have recognized two movement stages: 1) alveolar eruption, the time at which there is no apparent alveolar bone over the tooth and 2) the attainment of the occlusal level.

SEQUENCE

In one of our earlier studies we found that M_1, P_1 and M_3 invariably showed initial calcification first, second and last respectively. P_2 and M_2 varied in order of appearance and in some children began to calcify at the same time. Siblings of the P_2 M_2 children tended to the P_2 M_2 sequence and siblings of the M_2 P_2 children to the M_2 P_2 sequence more often than would be expected on a chance basis. Youngsters with P_2M_2 formation sequence erupted their teeth in that order but

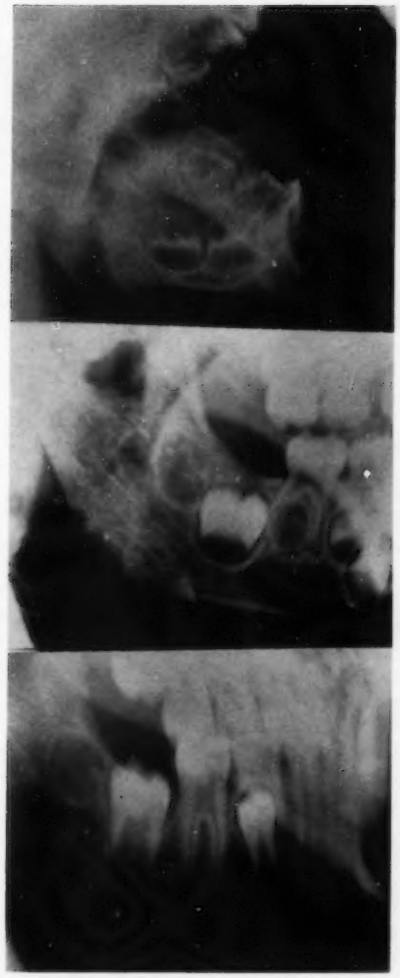

Fig. 1. Top, Beginning calcification of M_1. Middle, crown completion of M_1. Below, Apical closure of M_1, and alveolar eruption of M_2.

one-half of the M_2P_2 reversed their order.

Sex Differences

The fact that teeth are earlier in eruption in girls than boys and the further possibility of the hormonal factor affecting eruption lead us to compare formation time in the two sexes.

In general, girls were advanced over boys by an average of 0.32 years and by amounts up to 0.92 years. This sex difference is of the same order of magnitude as the sex difference observed in tooth eruption by Gleiser and Hunt from Hurmes' data. However, sex differences in dental development, while marked, are of a lesser order of magnitude than the degree of sexual dimorphism in osseous development. Figure 2 demonstrates the sex differences in tooth formation, tooth eruption, ossification in the knee and in thirty-six ossification centers in the shoulder, upper arm, hand, hip, knee and foot.

The standards of Pyle and Hoerr were used for knee ossification and those of Sontag and Pyle, and Sontag and Reynolds for the other centers. The large black dots show sex differences in tooth formation, the open circles the sex differences in knee ossification. Only lines of slope are shown for tooth eruption and the thirty-six bone centers. When the differences are related to age, girls are about three per cent ahead of the boys throughout. This value approximates the sex dif-

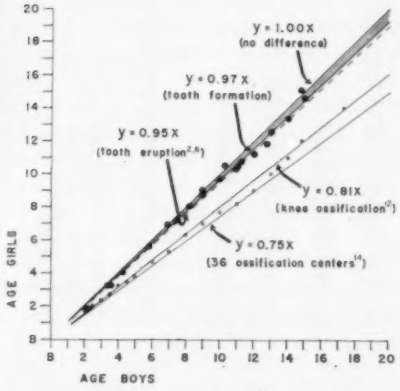

Fig. 2.

ference in eruption, but is, of course, much smaller than the nineteen per cent difference in the knee and the twenty-five per cent difference in the appearance of thirty-six ossification centers.

Variability

One important part of our findings concerns the variability of tooth formation. Specifically, we refer to the range of ages between which a given state of formation is found. For this particular work the two stages of movements were not calculated and the sexes were combined. Most contemporary references to tooth formation and its variability are derived directly or indirectly from the studies of Logan and Kronfeld in 1933 and from the tables of Kronfeld published in 1935. Their sample numbered twenty-five with only nine infants over one year of age and half less than three months of age at the time of death.

As soon as we began to compare our data with the Logan and Kronfeld tables as amended, altered, and condensed by many authors, we found their ranges far too narrow, being on the average one-third of the "true" range for any of the mandibular posterior teeth. Apparently the very limited number of cases available to Logan and Kronfeld was inadequate to provide a picture of the true variability of tooth formation.

It is possible that data derived from histologic sections are not at all comparable to roentgenographic findings. This objection would be most applicable to beginning calcification and least applicable to apical completion. Nevertheless, the discrepancies between our findings and theirs apply equally to beginning calcification, completion of crown formation and to apical closure. Moreover, it is ranges and not mean or median values that are under comparison. It is possible that the ranges are defined differently, for neither Logan and Kronfeld, nor Kronfeld are explicit on this matter. But if their ranges truly cover the extreme range, our fifth to ninety-fifth percentile ranges should fall short of theirs. The converse is true, however, as can be seen in Table I. The differences between the ranges given here and those in the literature, quite apparent in this table, are graphed in Figure 3. Using the Kronfeld table for comparison the ranges of variability in the literature are approximately one-third as great as ours.

With this fact in mind it seemed desirable to compare dental variability with the variability of other commonly measured maturational factors such as eruption of deciduous and permanent teeth, time of appearance of the first sixty-one centers of bone ossification, hand or wrist age, and age at menarche. Except for permanent tooth eruption and wrist age all data on variability were derived from our present population sample. Since developmental phenomena covering eighteen years had to be compared, the use of the coefficient of variation was adopted.

All values were corrected to conception, rather than to birth, since the latter procedure resulted in spurious high values of the coefficient of variability for the earliest developing phenomena. Accordingly, a group correction of .75 years was added to all values. As can be seen in Figure 4, tooth formation proved no more variable and often less variable than the age-developmental variability of menarche, tooth eruption, hand age or the appearance of ossification centers. Under these circumstances we believe that tooth formation affords a more definitive and useful estimate of chronological age in children of white ancestry when this is not known.

TABLE I

VARIABILITY OF $\overline{P_1}$—$\overline{M_3}$ AS GIVEN BY VARIOUS AUTHORS

Mandibular Tooth	Logan and Kronfeld	Kronfeld, Holt and Mc Intosh, Wilkins	Schour and Massler, Arey	Spector	This Study (Percentiles 5th—95th)
		Beginning Calcification (Years)			
P_1	1.50—2.00	1.75— 2.00	1.50— 2.00	1.75	1.6— 3.0
P_2	2.00—2.50	2.25— 2.50	2.00— 2.50	2.50	2.7— 4.7
M_1	0.08—0.33	Birth	Birth	Birth	0.04— 0.24
M_2	2.00—2.50	2.50— 3.00	2.50— 3.00	2.75	2.8— 4.8
M_3	7.00—9.00	8.00—10.00	7.00—10.00	7.00—10.00	7.5—10.9
		Crown Completion—(Years)			
P_1	....	5.00— 6.00	5.00— 6.00	....	6.0— 8.1
P_2	....	6.00— 7.00	6.00— 7.00	....	6.7— 9.3
M_1	....	2.50— 3.00	2.50— 3.00	....	3.1— 4.9
M_2	....	7.00— 8.00	7.00— 8.00	....	7.3—10.2
M_3	....	12.00—16.00	12.00—16.00	....	12.0—17.1
		Apical Closure (Years)			
P_1	....	12.00—13.00	12.00—13.00	12.00—13.00	11.2—14.0
P_2	....	13.00—14.00	12.00—14.00	12.00—14.00	12.1—15.4
M_1	....	9.00—10.00	9.00—10.00	9.00—10.00	8.8—11.6
M_2	....	14.00—15.00	14.00—16.00	14.00—16.00	12.8—17.6
M_3	....	18.00—25.00	18.00—25.00	18.00—25.00	Under 18 to over 26

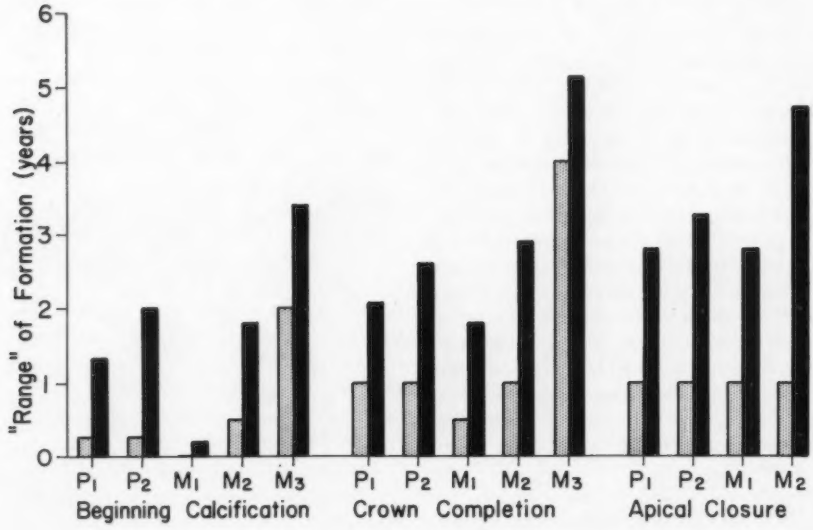

Fig. 3

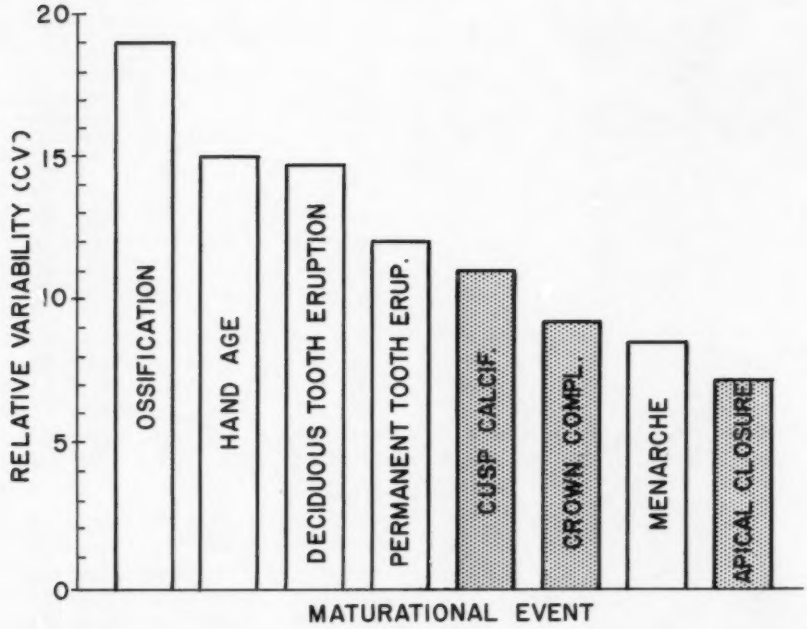

Fig. 4

Genetics and Tooth Formation

From our analyses of monozygotic and dizygotic twin pairs and siblings of both sexes we believe that tooth formation, to a large extent, is gene-determined. In monozygotic twin pairings correlations of tooth formation range from 0.75 to better than 0.9. Correlations among dizygotic pairings from triplet sets approximate 0.3, the same order of magnitude as sibling correlation. These findings are consistent with the hypothesis that the timing of tooth formation is largely, but not necessarily exclusively, gene-determined. This is the same conclusion we reached earlier with respect to the formation sequences of P_2 and M_2.

Interrelationships

We have examined interrelationships in tooth formation in considerable detail. This has been a lengthy task since we have used five stages for five teeth for two sexes. We have found that intercorrelations involving tooth calcification stages alone and tooth movement stages alone are higher than those relating tooth calcifications to tooth movement. In addition, we have correlated tooth formation with such variables as stature, weight, subcutaneous fat thickness, bone age, menarche in girls and the time of epiphyseal union of the tibia in both sexes in order to determine the relationship of nutritional status, size and sexual maturation to the rate of tooth formation. Studies in this area are still in progress and only part of our findings are summarized here.

During infancy and childhood interrelationships between tooth formation and general growth and development, though positive, are low and rarely

TABLE II

CORRELATIONS BETWEEN TOOTH FORMATION AND OSSEOUS DEVELOPMENT, STATURE, WEIGHT AND FAT THICKNESS

Tooth and Stage of Development	Measure of Growth or Nutrition	Age	No.	Correlation	Significance Level
M_2 Beginning Calcification	No. of hand-wrist centers	3.5	98	0.033	NS
M_2 Crown Completion	"Bone Age" (Greulich & Pyle)	9.0	100	—0.274[1]	0.05
M_3 Beginning Calcification	"Bone Age" (Greulich & Pyle)	9.0	83	—0.305	0.01
M_2 Beginning Calcification	Thoracic fat	3.5	54	—0.030	NS
P_1 Beginning Calcification	Height	2.0	150	—0.114	NS
P_1 Beginning Calcification	Weight	2.0	151	—0.111	NS
P_1 Crown Completion	Height	7.5	167	—0.262	0.01
P_1 Crown Completion	Weight	7.3	166	—0.171	0.05
M_2 Occlusal Level	Height	12.3	43	—0.262	NS
M_2 Occlusal Level	Weight	12.3	43	—0.231	NS

[1] i.e. children advanced (9 or earlier) in tooth formation have, at a uniform age, a higher bone age, hence the negative correlation.

significant. In Table II are noted some relationships between tooth formation and stature, weight, number of carpal centers, bone age and fat. In general we can report a relationship and in the expected direction. The correlations from infancy through early adolescence are far from high, averaging about 0.2. Correlations with the number of carpal centers during the first few years of life and with bone age (Greulich and Pyle)in preadolescence similarly suggest osseous advancement associated with dental maturation. Although fatter boys and girls in the Fels series are demonstrably taller and advanced in bone age, they are only slightly and not significantly ahead in tooth formation.

As adolescence approaches, there is an increasing association between maturational status and tooth formation. Using menarche as a measure of sexual maturation in girls and tibial union (the age at union of the proximal epiphyses of the tibia) in both sexes, we have investigated the timing of these phenomena in relation to the timing of tooth formation and movement. As shown in Table III, sexual maturation is more highly correlated with tooth formation and especially tooth movement, than proved true of

TABLE III

CORRELATIONS BETWEEN SECOND MOLAR DEVELOPMENT AND SEXUAL AND OSSEOUS MATURATION

	Tooth and Stage of Development	Correlated with Age at	Sex	No.	Correlation	Significance Level
M_2	Crown Completion	Menarche	f	63	0.335	0.01
M_2	Alveolar Eruption	Menarche	f	35	0.621	0.001
M_2	Occlusal Level	Menarche	f	35	0.614	0.001
M_2	Apical Closure	Menarche	f	15	0.287	NS
M_2	Crown Completion	Tibial union	m&f	101	0.265	0.05
M_2	Alveolar Eruption	Tibial union	m&f	45	0.511	0.001
M_2	Occlusal Level	Tibial union	m&f	26	0.544	0.01
M_2	Apical Closure	Tibial union	m&f	28	0.338	0.05

somatic growth. Correlation between certain stages of tooth formation or movement and menarche reached as high as 0.62 while correlation with tibial union ranged from 0.12 to 0.54 in both sexes with an average of 0.40 for thirty-six correlations.

While it is obvious that the teeth are not unusually accelerated or retarded in their development when growth is faster or slower, the explanation for the relationships between dental formation and general maturation requires further investigation. It is evident from clinical studies that tooth eruption is accelerated in early-maturing girls; this leads to the possibility that to some extent steroid hormones of gonadal and adrenal origin may be involved in the relationship between sexual maturation and dental development.

We are now working with a pediatric endocrinologist in an attempt to evaluate the effects of certain endocrinopathies on the development of the teeth. While we thought advanced dental maturation to be associated with certain endocrinopathies and retarded dental maturation with others, we now believe that additional information must be gathered before we can say anything definite about the hormones involved or their effects on tooth formation.

Fels Institute

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Discussion

Dr. John W. Richardson

In discussing this very comprehensive study of tooth maturation I can only admire the detail into which Dr. Lewis has gone, and hope that I can be helpful to him. He has included sex differences, the similarity of siblings and the actual eruption of the permanent teeth — the order of which I had always felt had no rhyme or reason.

The Bolton Fund has graciously released to me some material from many years ago and may I point out that one of the first standards that they published was the table showing the time of beginning calcification of the permanent teeth. This served as a rough method of assessing skeletal age from birth to the ninth year.

In 1940 I was assigned the problem of collaborating with Dr. Carl Francis, of the Brush Foundation, on the program of the A.D.A. Dr. Francis presented five cases analyzed as to growth and development from the long bone and joint viewpoint. My part was to compare his findings with those of the cephalometer.

After a review of a number of series judged by the Bolton and Brush groups as being normal, I established a graph to determine the skeletal age from shortly after birth until nearly adulthood. To apply this to a given individual a standardized cephalometric x-ray is taken, the total amount of calcification of the permanent dentition in one quadrant is measured and the number of centimeters is applied to the chart. (Slide) Where the measurement crosses the white line on the graph indicates the individual's skeletal age. This technique seemed to give answers very similar to those of Todds' *Atlas of Skeletal Maturation.*

It is possible that if Dr. Lewis arranged his material in the order of skeletal age, rather than chronological age some of his variables might be lessened.

Unoperated Oral Clefts At Maturation*

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INTRODUCTION

Skeletal aberrations in cleft palate adults have frequently been studied by comparing normal and surgically repaired cleft palate subjects. A considerable number of these studies have been conducted by orthodontists who are particularly interested in the growth and development of the dentofacial skeleton.[1-4] In the cleft palate individuals the maxillary region has consistently been recognized as the primary area of dysplasia. The maxillary jaw has been described as disproportionately short and retruded within the facial profile.

Several explanations for the underdeveloped maxillae in cleft palate adults have been projected. Perhaps the one explanation which has received the most critical consideration pertains to the effects of palatal surgery upon the growth of the maxillary jaw.

If it is assumed that smaller maxillary dimensions in postoperative cleft palate adults result from growth disturbances, then it seems necessary to establish that smaller maxillary dimensions do not occur if the variable of palatal surgery has not been introduced. If the logic of this thought is accepted, a comparative analysis of mature normal and unoperated cleft palate individuals should yield data pertinent to the major area of inquiry. In other words, a comparative analysis of this type should permit some objective comments as to whether unoperated cleft palate subjects can and do attain mature skeletal dimensions.

PROCEDURES

With this as background, cephalometric records of forty-nine adults, with unoperated clefts of the palate, were compared with analogous records of thirty normal or noncleft adults. For purposes of analysis, the cleft palate sample was subdivided into a group of twenty-two subjects possessing unoperated posterior clefts of the palate and twenty-seven subjects with unoperated unilateral clefts of the palate. Twenty-one, or a majority of the subjects with complete unilateral clefts of the palate, had surgical repairs of the cleft lip. In most instances, lip repair was undertaken during early adolescence or at an age much later than that presently considered conventional for primary lip repair.

The subjects ranged from fifteen to fifty-seven years of age and can be considered to represent a relatively mature stage of development. All of the subjects were Puerto Ricans who came to five different health centers on the island so that study records could be obtained. A full series of cephalometric roentgenograms was obtained on each individual, but only the lateral headplates were analyzed for this study. The technique of obtaining cephalometric radiographs has been described elsewhere and need not be repeated here[5]. The x-rays obtained fulfilled the principles of cephalometric roentgenography and, as a result, permit pre-

*The data in this report are from a study conducted in Puerto Rico by the Division of Dental Public Health, U. S. Public Health Service, Department of Health, Education, and Welfare and Puerto Rico Department of Health.

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cise quantitative measurements and comparisons. In accumulating records however, it was necessary, at these five different health centers, to adapt the head holder to the differing x-ray setups. These unfortunate, but unavoidable factors, possibly may have introduced slight variability in the x-ray records obtained. To compensate for any possible errors which might be reflected in absolute linear measurements, the present analysis has been restricted to angular and proportional measurements of skeletal factors. This restriction in the manner of reporting measurements should not be considered a limitation in the present analysis.

Proportional and angular measurements are particularly suitable, if not preferable, in a cross-sectional study of this type. In comparing cross-sectional samples, individual variation in the dimensions of the head must be considered. For example, a large individual may reveal larger linear measurements than a smaller individual. Yet both may be comparable in age and development. This inequity can be partially overcome by utilizing angular and proportional measurements.

Findings

As stated, the primary objective of this study was to determine whether the maxilla in unoperated cleft palate adults is normal in size and position. In following this objective, a definitive analysis of the lower face was needed to determine whether mandibular dimensions and positions were comparable in the normal and cleft palate subjects. Mandibular analysis was also required to serve as a basis for proportional measurements of the maxilla.

The anteroposterior position of the chin was evaluated in reference to the cranium in the three groups; the normal adults, the adults with unoperated unilateral clefts of the palate and the adults with unoperated posterior clefts

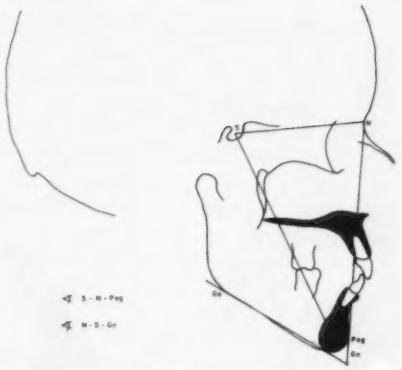

Fig. 1. Tracing of a cephalometric x-ray depicting the angular measurements used to evaluate the position of the chin.

of the palate. The position of the chin was determined by reading the angle formed by a cranial base line drawn from the center of the pituitary fossa to nasion and a line drawn from nasion to the most anterior point of the chin, pogonion (Fig. 1). The horizontal position of the chin was found to be comparable in the three groups with mean readings of 79.76° for the controls, 79.75° for the unilateral clefts and 79.23° for the posterior clefts. A second angular reading (N-S-Gn) was made to evaluate the vertical position of the chin (Fig. 1). Once again, the mean readings were closely comparable in the three groups. It can be concluded on the basis of these two angular measurements that the mandible in these cleft palate adults was normal in anteroposterior and vertical positions relative to the cranium and the face.

To define mandibular size in addition to its position, linear measurements were made of mandibular ramus height and mandibular body length. Ramal height was measured from the summit of the condyle to the gonial angle (Fig. 2). Proportions of the mandibular ramus height to the mandibular body length were established for each case.

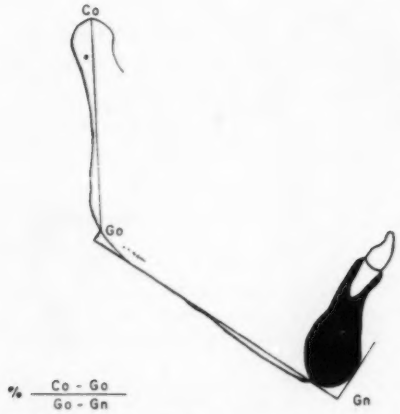

Fig. 2. The linear measurements for the vertical height of the ramus and the length of the body of the mandible.

On the basis of the mean value, ramal height was found to be 82.17 per cent of body length in normals, 82.61 per cent in the unilateral cleft palate group and 80.38 per cent in the posterior cleft palate group. These values indicate a close similarity in proportional size of mandibular components in all three groups.

Statistical analysis of the mandibular measurements did not reveal any significant differences. Thus, it is concluded that the mandible in unoperated cleft palate adults is normal in size and position. Statistically, these results provide a reliable basis for utilizing the mandible to proportionately evaluate measurements of the maxilla.

Maxillary dimensions were defined by measurements of the horizontal and the vertical aspects of the maxilla. The vertical height of the anterior aspect of the maxilla was evaluated by determining its proportional dimension relative to the vertical height of the total face. Anterior maxillary or upper facial height was measured from nasion to the anterior nasal spine (Fig. 3). Total face height was measured from nasion to gnathion.

The anterior vertical dimensions of the maxilla in cleft palate groups were only slightly shorter than normal. Means showed that the average anterior maxillary height was 43.24 per cent of the total facial height in the unilateral group, 43.62 per cent of the total facial height in the posterior group and 44.86 per cent of the total facial height in normals. Statistical analysis of these values for anterior maxillary height revealed that the unoperated cleft palate adults do not differ significantly from the normal adults. This finding is in direct contrast to generalized statements in the literature which have described many surgically corrected cleft palate adults as showing deficiencies in the anterior aspects of the maxilla.[6,7,8,9]

Not only was the anterior maxillary height found to be comparable in the normal and unoperated cleft palate adults, but the anterior limit of the maxilla was also found to be normal in its position relative to the cranium. The angle formed by the cranial baseline and a line drawn from nasion to the anterior nasal spine was measured (Fig. 3). The differences between the

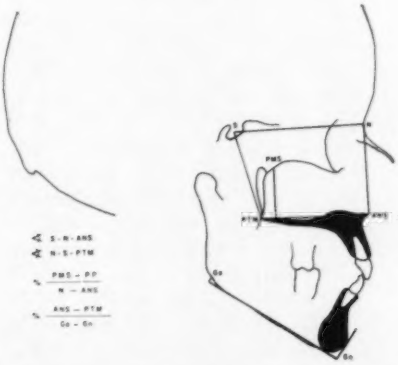

Fig. 3. A tracing to show the linear measurements utilized for establishing proportions.

three groups were very slight with averages of 85.38° for the normal adults, 84.07° for the unilateral clefts and 85.09° for the posterior clefts. These were not found to be statistically significant, indicating that the upper face was not retruded or retropositioned in the unoperated cleft palate adults when compared to the normal subjects. Thus, the anterior aspect of the maxilla in the unoperated cleft palate subjects was normal in its vertical dimension and in its position.

The posterior aspect of the maxilla was also studied in its vertical dimension and position. Posterior maxillary height was first measured and then established in proportion to the anterior maxillary height. In preparation for measuring posterior maxillary height, the tuberosity of the maxilla as it ascends to form the anterior outline of the pterygomaxillary fissure was traced from the lateral headplate. This surface continues upward and then curves sharply forward to become the superior surface of the maxilla as it progresses forward to form part of the floor of the orbit. On this curved posterior-superior outline of the maxilla, the most superior and most posterior points were selected. A point midway between these two points was designated as the posterior maxillary summit (PMS). From this point the vertical distance to the palatal plane was measured and recorded as the posterior maxillary height (Fig. 3). This dimension was then proportionately studied in comparison with the respective anterior maxillary height.

The means showed the posterior maxillary height to be 48.68 per cent of the anterior maxillary height in normals, 47.21 per cent in unilateral clefts and 50.43 per cent in posterior clefts. Statistical tests revealed no significant differences between the three groups, indicating that the unoperated cleft palate subjects showed normal vertical dimensions in the posterior as well as the anterior aspect of the maxilla. Angular measurements were also obtained to determine the position of the posterior limits of the maxilla relative to the base of the skull. These measurements again were found to be comparable in all groups.

Comparatively, no discernible difference between the normal and unoperated cleft palate adults was revealed in the vertical dimensions of the maxilla. To complete the appraisal of the maxilla, an analysis of the anteroposterior dimension of the maxilla was undertaken. The maxillary body length was measured from the anterior nasal spine to the point of intersection of the palatal plane as it crossed the tuberosity of the maxilla (Fig. 3). Designation of this point of intersection as the posterior landmark for maxillary length was necessary because of obvious deficiency in the posterior aspect of the hard palate in some of the cleft cases. This deficiency varied markedly from one cleft palate subject to the next and was most evident in the posterior cleft cases. A proportion was established between the length of the maxilla and the length of the mandibular body. Greater variation was found in this proportional measurement in the cleft palate groups than in the normal groups. The average anteroposterior dimension of the maxilla was found to be shorter in the unoperated cleft palate subjects. Means revealed the anteroposterior dimensions of the maxilla were 66.26 per cent of mandibular body length in the unilateral cleft palate group, 67.37 per cent in the posterior cleft palate group and 70.29 per cent in the normal group. Tests failed to show these differences as statistically significant, although "t" values can be described as approaching significance. In summarizing the results of all statistical appraisals, it must be concluded that horizontal and vertical dimensions of the maxilla and their

TABLE I

AVERAGE ANGULAR AND PROPORTIONAL MEASUREMENTS

A. Angular Measurements (in Degrees)	30 Control Subjects		27 Unoperated Unilateral Cleft Palate Subjects		22 Unoperated Posterior Cleft Palate Subjects	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
1. S-N-Pog	79.76	3.53	79.75	4.87	79.23	5.46
2. N-S-Gn	68.78	3.56	68.44	5.06	69.73	5.72
3. S-N-Ans	85.38	11.39	84.07	5.69	85.09	4.97
4. N-S-Ptm	72.38	3.14	70.57	3.47	72.48	4.42
B. Proportional Measurements (In Percentages)						
1. N-Ans / N-Gn	44.86	2.62	43.24	8.51	43.62	3.04
2. Pms-(Ptm-Ans) / N-Ans	48.68	5.56	47.21	6.53	50.43	5.81
3. Co-Go / Go-Gn	82.17	6.72	82.61	9.24	80.38	7.80
4. Ans-Ptm / Go-Gn	70.29	5.83	66.26	6.10	67.37	5.51

relative positions within the craniofacial complex were found to be normal in both of the unoperated cleft palate groups. (Table I)

Discussion

The present comparative analysis permits the generalization that the mature skeletal relationships in unoperated cleft cases do not differ significantly from those of mature normal individuals. These findings are in striking contrast to cephalometric studies describing skeletal characteristics of mature cleft palate subjects who have had surgical correction for cleft palate.[6,7,8,9] Especially pertinent are the results of Graber's study of surgically repaired cleft palate patients in which the maxilla has been described as deficient in its anteroposterior and vertical dimension, as well as aberrant in its positional relationship to the rest of the facial skeleton.[1,6] Whereas present results are in agreement with Graber's analysis of unoperated cleft palate patients and in striking contrast to his descriptions of postoperative cleft palate adults, clinical interpretations of the present data differ somewhat in philosophy.

First of all, it is emphasized that the maxilla itself, in its contour and in its relationship to the rest of the craniofacial skeleton, was found to be comparatively normal in unoperated unilateral and posterior cleft palate cases who had reached a relatively mature stage of development. However, the statement that the maxillary complex is normal in unoperated cleft palate cases cannot be accepted. Cleft palate involves an initial aberration primarily located in one aspect of the maxilla — the palate. While the rest of the maxillary complex assumed normal skeletal dimensions and contour, the cleft aberration continued to exist and obviously was still a problem (Figs. 4 and 5).

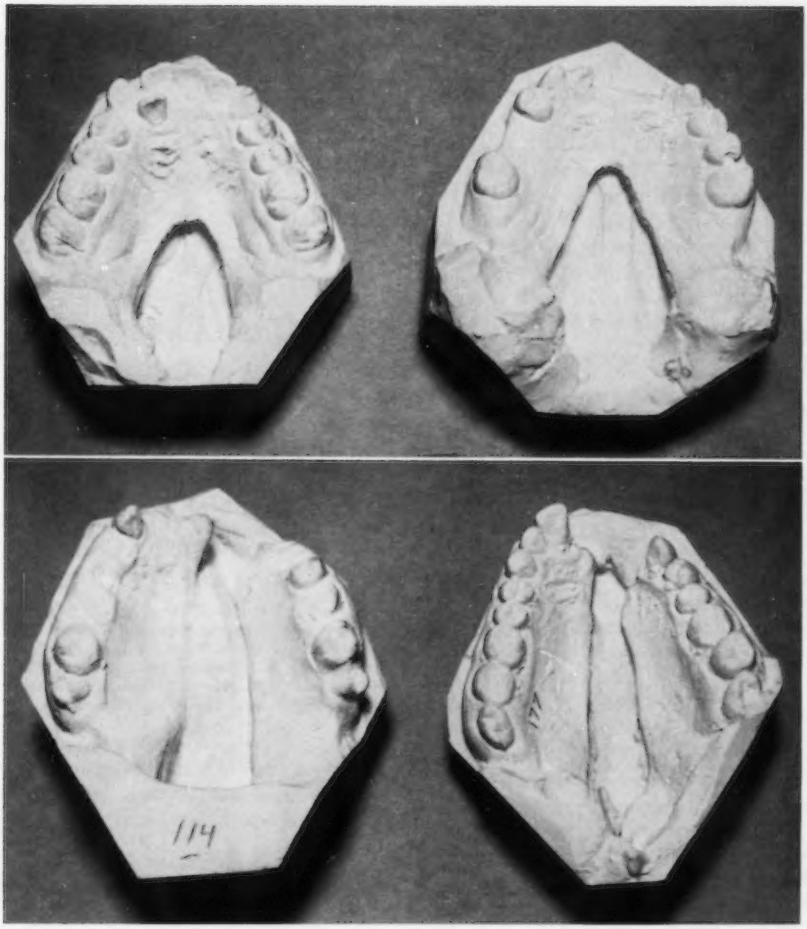

Fig. 4, above. Cast reproduction of two posterior clefts of the palate.

Fig. 5, below. Models of two adults with unoperated unilateral clefts of the palate.

Secondly, if comments are to be made pertaining to the effects of surgery on the growth of the maxilla in cleft palate subjects, some of the other contemporary concepts should be acknowledged. Whereas some investigators do not contest maxillary deficiency in some postsurgical cleft palate adults, they seriously question deficiency as the inevitable outcome of palatal surgery.[10,11,12] It has been suggested that a goodly number of surgically treated adults in previous studies were subjected to traumatic surgery, poorly timed and poorly executed. Thus, the palatal surgery, per se, is not thought to be entirely responsible for the recognized disturbance in growth. In sup-

port of this observation data has recently been presented which shows that the maxillary region can and does grow normally in many postoperative cleft palate subjects.[10, 11]

More recently attention has been focused upon the criteria applied in selection of patients for surgical correction and upon differences in the timing and techniques applied. The modifications in the rehabilitative planning for cleft palate individuals actually have not been in effect long enough to permit a definitive and critical appraisal of their efficacy as reflected in mature craniofacial skeletons. To date, some encouraging cephalometric reports on youngsters are available. These, of course, do not record maturity.

The present data seems valuable in two respects:

1. The normal facial skeletons in unoperated unilateral and posterior cleft palate subjects at mature stages of development seem to refute the contention that cleft palate individuals may present a fundamental difference in their potential for adequate normal facial development (Fig. 6). As an explanation of retrusion of the maxillary jaw, it has been suggested, at times, that the genetic potential for full maxillary growth is not present in individuals with clefts of the palate. It seems obvious, after studying the unoperated cleft palate adults, that these individuals possess the genetic potential for attaining full anteroposterior maxillary development.

2. Present data has demonstrated that unoperated unilateral and posterior cleft palate patients possess the potential for normal growth. Such a finding must be accepted as supportive evidence that *certain* surgical procedures can interfere with growth. Certainly, these results should be accepted by surgeons as a valid basis for a critical reevaluation of their current criterions for surgical treatment and the current procedures applied in palatal reconstruction.

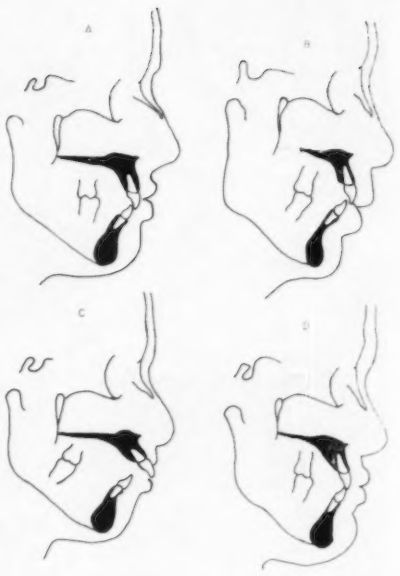

Fig. 6. Cephalometric tracings of four of the subjects with unoperated clefts of the palate. Each seems to have reached a mature state of facial development. Note the range in variation of facial appearances; this seems within the range of normal.

Summary

Cephalometric x-rays of forty-nine adults with unoperated clefts of the palate were compared with cephalometric records of thirty noncleft adults. The subjects ranged from fifteen to fifty-seven years of age and were located on the Island of Puerto Rico. A definitive analysis of the upper and lower face was undertaken to determine whether the dimensions and positions of the jaws were or were not comparable in the normal and cleft palate subjects.

The study showed that the mature skeletal relationships of the jaws did not differ significantly in the unoperated

cleft palate adults when compared with the normal adults. Particularly, the dimensions of the maxilla and the positions of the maxilla within the craniofacial complex were found to be normal in the cleft palate subjects. Clinical interpretations of the results of this study are presented.

Eastman Clinic

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The Formation And Functioning Of Group Orthodontic Practice

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INTRODUCTION

Can you afford to be gone from your active practice for an extended vacation without neglecting the youngsters under your treatment? Is it conceivable that you could become ill for a considerable length of time and not jeopardize your practice? Have all possible accommodations been made for the patients to whom you are morally obligated in the event of your death? Suppose you live to that ripe old age of retirement; could you then afford it? Would the going value of the practice you may have spent the better part of your lifetime building realize a fair value upon disposal by yourself at retirement or by the representatives of your estate at your death; or would your practice, as is so common with most of us, be sold for the discounted value of the accounts receivable plus the value of the furniture and equipment, the latter being almost always nearly or fully depreciated? These questions confront all of us and, in this present day of high individual income, inheritance and estate taxes, the impact of an improper solution or no solution whatsoever may have a dire effect upon the beneficiaries of your estate. Blake[1] was certainly aware of this in his writing, "there are dentists who feels that a dental office with an extensive practice covering many years and earning a sizable income should represent a tangible asset after they are gone. Others know that, upon their death, other than the physical equipment and perhaps accounts receivable, the practice cannot be sold for it has no value. Many heirs have been shockingly disillusioned thereby."

Since orthodontics, in keeping with almost any field of medical or dental practice, encompasses so many personal relationships, it is, at best, difficult for the orthodontist to personally dispose of his practice; and its ultimate disposal, if left to a widow, more often than not presents insurmountable problems. In either event, it is necessary to obtain a qualified orthodontist who would not only be competent but conscientious as well in completing the unfinished cases.

Wouldn't it be a blessing if this weren't even a consideration with which to deal? In fact, wouldn't it be a panacea to orthodontists if all the above-mentioned eventualities could be dismissed entirely, knowing that your moral obligation to your patients, your future for your family, and your peace of mind have all become realities. While there is, of course, no hard and fast solution to all of those problems, I believe it is possible for many of us to solve a good portion of them through the practicing of orthodontics in groups. I base this statement upon four years of personal experience.

Stating his views regarding group orthodontic practice, Gibbens[4] states, "If orthodontic practice is to fulfill its responsibilities in full measure, then it must grow and develop from the limited one-man setup to a highly efficient, carefully coordinated unit capable of producing not only the highest quality of service but an increased availability of service in its respective community."

Garvin[3] editorializes his thoughts re-

garding group practice this way. "Dentistry has scarcely more than explored the potentialities of group practice, while medicine has made much progress in this direction. It has always seemed strange that there are so few partnerships among dental practioners. In dentistry, group practice is the ideal method of practice and the many advantages are worthy of careful study . . . . The star of group practice is rising rapidly."

In a recent publication by Foley, Crow and Halker[2] it was pointed out that, "We are practicing in an era of great technical progress. Dentistry has much to offer the public in health and happiness, but our production methods need to be modernized. Group practice offers both the patient and the dentist physical, financial and moral benefits."

In addition to the undeniable fact that more than one orthodontist is essential in forming such a functioning unit, important ingredients for a successful operation are compatibility, understanding, trust, confidence, devotion and, of course, similar basic concepts of orthodontic philosophies and treatment plans. Once these prerequisites have been accepted, the mechanics of a group practice can be undertaken. I shall be referring to our particular partnership entirely throughout, solely because of my firsthand experience with it, being cognizant, however, that other methods might prove as efficient.

Legal Documents

After seeking the advice of legal counsel and explaining our goals and/or objectives, which shall be taken up in detail later, it was suggested that the following legal instruments would be required: an Agreement of Sale, an Agreement of Partnership, and a Partnership Buy-and-Sell Agreement.

Agreement of Sale This instrument was drafted to equalize the existing practices and to adjust for and compensate the oldest partner who had the largest practice. A formula for arriving at this figure could, of course, vary among groups depending upon the circumstances. In our particular case, it was agreed that the fairest evaluation for all concerned could be attained by taking the following into consideration:

1) The relative value of equipment, supplies and furniture devoted to each of our separate practices. Since the amounts here involved were substantially equal, no problem was encountered.
2) The gross income realized by each of the three members during the previous year.
3) The amount of work under contract, but not yet completed, in each of the practices analyzed.

After studying the above factors, it was decided that the oldest member should be compensated for the largest amount of work being brought into the partnership. A closing date was set for the single proprietorships. All cash, accounts receivable covering work completed to the date of the formulation of the partnership, as well as all debts and encumbrances of each party, remained the separate property of each member. The amount of good will for the oldest member was agreed upon and accepted as salable to the younger men. All assets were contributed to the newly formed partnership and capital accounts were equalized as good will payments were received by the oldest member.

Partnership Agreement This instrument deals with the capital to be provided to initiate the group practice, a statement as to profit and loss acceptances, equalization of the drawing accounts on a monthly basis, management, duties and restrictions, retirement, and death.

It was agreed by the three partners

that they should devote their full time to the affairs of the partnership excepting any active duty with the armed services in which any one or all might become so engaged. It was also understood that if and when illness or disability might occur to any of the individuals, he would be covered by full monthly compensation for a period of three months. If the disability continued beyond this period, the partner so affected would then draw one-half the monthly partnership drawing for an additional nine months, totaling a compensation of one year's duration. In the event that the partner couldn't return to the practice after the year, the remaining partners have the right to purchase the interest of the disabled partner. Terms state that the affected member is bound to comply.

The next consideration was temporary leaves for purposes of vacationing or attending orthodontic seminars or scientific meetings. Vacationing is to be credited at the rate of one month per year per member as he chooses, either all in one month, two two-week interludes, weekly or even on a daily basis. At any rate, it goes without saying that a meeting of the minds took place to the extent that only one member should be vacationing at any given time. As to the meetings, it was decided that as nearly as possible these would be attended on a rotational basis. However, as meetings were not deducted from vacation time, it was conceded that if one partner did attend more meetings, over a period of several years, it would be equalized among all concerned. Of course, local or regional meetings are attended by all members.

After many enjoyable years of active practice, one month of vacationing each year, and compensation for illness for extended periods, one still must face the realization of aging. Hence, it was a logical next step that we consider the how's and wherefore's of retirement. It could be so effected by any member by giving written notice to the other partners six months in advance of his intended retirement. This, in effect, is a buffer, whereby the remaining partners might accumulate the necessary capital to buy the retiring member's share or allow it to be sold to another orthodontist in order to maintain the workload already established. Details are likewise set up to the extent of semiretirement of any of the partners. In later years, as the efficiency of the older man diminishes and/or his drive disappears, he need not be content with hobbies to the exclusion of orthodontic practice entirely. Rather, he may continue to practice as little as he desires, for the patient load can be adjusted among the actively practicing members to account for the limited practicing. This truly substantiates the premise of Rilkin[5] and associates who state, "Dentists faced with . . . . . an overburdening practice may seek relief in several ways. A partnership would afford several advantages including increased income, lighter workload and increased freedom, introduction of new methods and techniques, savings effected through decreased cost of maintenance."

Though grim, realism forces everyone to face the inevitability of death. This partnership, not being able to forestall or overcome this obstacle, simply combated it by provisions to be applied at the appropriate time. In the event of death, the benefactors of the deceased will receive one-third of the interest of the partnership, which would be the amount of his capital account plus or minus any credit or debit in his drawing account, to include also, however, a fixed valuation of good will. The valuation of the partnership is revised yearly by the members concerned.

Partnership Buy-and-Sell Agreement

In essence, this legal pact deals with

the procedural outline to be maintained in the event of the necessity of same, due to the death of any of the partners. Upon the death of a partner, it is mandatory that his heirs or estate sell to the surviving partners the deceased partner's interests. The net value of the partnership is determined yearly by the partners themselves and this becomes binding for a one-year period on any survivors of the deceased partner and is so drafted to be binding on the state and federal government for inheritance and estate tax purposes. To help provide all or a portion of the funds necessary to finance the obligations arising under this agreement, life insurance was procured. The life insurance program was set up whereby each partner owned the policies on the lives of the other two partners. The amount of insurance was again affixed according to the value placed on the partnership. It is provided, of course, that in the event the insurance policies exceed the net value of the partnership, only that amount stipulated as the true net value shall be paid to the decedent's estate.

Physical Plant

Having consummated the legal procedures whereby our three individual practices became one, the necessity for a physical plant became real. We secured the entire second floor of a small downtown building being renovated for medical and dental suites. It was constructed to our specifications and to the design we felt would be most functional to best utilize auxiliary personnel. Figure 1 depicts part of our reception room. The mural represents the legend of the Bridge of the Gods and Celilo Falls which are points of interest in our Pacific Northwest vacationland. Figure 2 represents one of the four identical operatories. Each operating room has two units composed of chair, pedestal receptacle, Angle-Wuerpel table, and

Fig. 1.

light. The hinged door beneath the sink conceals the soiled towels as they are placed through the door. Immediately above the sink is located a retractable viewbox large enough to place a cephalometric film for study or explanation to parents. When not in use it drops to the level of the countertop and the light switches off automatically. The portable engine is used in any of the operatories as needed. When not in use it is stored away from the chairs thereby allaying the fears of many junior patients due to its very presence. In Figure 3 is seen the tooth brush area. Both sides of the sink have identical pigeon holes which house the brushes of all our patients under treatment (note the reflection in the mirror

Fig. 2.

Fig. 3.

of the model boxes). This area serves a very functional and important part in our scheme of operation. Not depicted are the library where we hold consultations; the x-ray room where we have our own cephalostat holder, dental x-ray unit, the photographic set-up; the bookkeeping or reception area proper; the employee's lounge; or the areas where the models of the patients are stored. Per se, the area we occupy approaches 2400 square feet with every foot utilized to its capacity.

Handling of Patients

With a complete physical plant now ready, one practice for three men awaiting treatment, the next major consideration was the modus operandi. Just how should these patients be handled? Should each man have his own patients thereby resulting in individual practices once again with inequities in the patient load; or should it become a group project whereby every patient was treated by all the doctors? We chose the latter method and in less than one month we realized our course was the best one, both as to the service rendered and the acceptance it had with the patients and parents concerned.

For ease of understanding our procedures, let us follow one case from start to finish. The patient is referred to one of the doctors who makes the preliminary examination at the chair. If the patient is not ready for treatment, he is placed on our recall system for systematic periodic examinations. If full orthodontic treatment should be instigated at this time, another appointment is made for the patient to get all the records assembled that will be needed for a complete diagnosis and treatment plan. On this following appointment the patient is ushered into the room where the dental hygienist readies the patient for the impressions, calls the doctor to take the impression and gets a complete physical history. The x-ray technician then takes the cephalometric x-ray, the full mouth intraoral x-rays and the photographs. This procedure takes approximately one and one-half hours of which ten minutes is the doctor's time. The patient is dismissed and another appointment given for consultation with the parents and patient, once again with the same doctor.

After all models are trimmed and polished, the intraoral x-rays mounted, the cephalometric x-ray traced and measured using the Down's analysis, and the photographs developed, everything is in readiness for diagnosis and treatment planning. The three doctors study each and every record of the individual case, make individual diagnosis and treatment plans and then compare notes. If no difference is noted, another case with all its records is studied. This, I might add, is the exception. Usually, one of us thinks of a particular factor the others had not. It is then openly discussed among us. This provides a wonderful, built-in study club. Once the final decision is reached as to the treatment outline, it is dictated into the recording machine for placement on the individual's worksheet by the stenographer. Many times differences remain as to treatment pro-

cedures. In this event, the doctor originally consulted has the final say as to how this case shall be treated. Notations are made, however, about the various differences and periodically checked on as to the proper diagnosis, thereby furthering our study-club feature of diagnosis. Throughout treatment the patient's worksheet is constantly referred to, refreshing our minds as to the treatment plan and the objectives to be achieved.

When the appointed time arrives for the consultation, the parents are ushered into the library, not the operatory, to discuss the case with the doctor. He explains in detail, as is routine in most orthodontic offices, the reasons for the records, what they show us, and then the eventual solution to the problem. During the course of this appointment it is pointed out that the other two doctors will likewise be working on the child for they helped diagnose the case and are just as familiar with it. It is pointed out that some of the advantages for the patient, once the case is started, are that the doctors can consult regarding the case whenever necessary, a doctor can take a vacation, become ill, or even pass away, and yet they have the assurance of their child's case continuing to a successful completion. Admittedly, when this treatment method was first instigated, there was some hesitancy on the part of some patients or parents because they wanted just one particular doctor, not the other two. After pointing out the advantages of having the services of three, if they still insisted on the one, notations were made to that effect and the one operator attended that case exclusively. It is still the routine in our office that if this intent is made known by the patient, the referring dentist, or the parent, it shall be carried out to their liking as far as possible. We have proved beyond question that better service is given if all three share the work on each case and have found that less than five per cent of our new cases demand this individual attention.

In quoting the fee, likewise, it is commented that this is what we three have decided is fair and equitable. Of course, all professional offices are asked about discounts due to business associations, service club affiliations, friendships, relatives, etc. With our partnership it is extremely easy to reply with the summation that I would consider giving a reduction for the treatment but, truly, the other men are as involved and therefore it is not fair or just to them. This usually concludes any further dissertation along these lines. I don't mean to infer that considerations are never given. Circumstances dictate many adjustments and changes are certainly made; however, only after all three doctors concur.

Once this consultation is concluded and arrangements made as to extraction letters, various notations to dentist, financial arrangements with the bookkeeper, etc., the appointments are made for the patient to begin the orthodontic treatment.

Our appointment book has an additional column next to the name column on which is recorded the intended operative procedures for the patient on that appointment. When the patient appears for the appointment, he immediately reports to the receptionist. Whenever any of the three doctors is ready for a patient, his assistant talks with the receptionist on the telephone intercommunication system. The receptionist informs the assistant that she is sending in (patient's name) to pinch and cements bands on such and such teeth, change the arch, construct a headgear or whatever has been ordered. Now, as the patient walks into the operatory, the doctor has already been told who is entering and is not fumbling for the name but rather has a cheerful, "Hello (patient's name)." He

has been told the order for today was, for example, to pinch and cement the maxillary first molars and take an impression for a biteplate.

After the bands have been cemented and properly isolated to prevent moisture from seeping into the fresh cement, the patient is referred to the hygienist who will do the scaling of the excess cement and again make ready for the impression of the biteplate. Until the hygienist is ready for the doctor, he is free to proceed with another patient. Before dismissing the patient to the hygienist, the assistant writes the patient's name on an appointment slip with a notation of what the doctor intends for the next visit and gives it to the patient. When the patient's work is done for the day, he is told to take the appointment slip to the receptionist who fills in the date and time on it and likewise places the patient's name and work order in her appointment book. The work order, of course, determines the amount of time the receptionist allots for the next appointment.

Our methodology for starting the majority of our full-banded treatment cases has become standardized enough that for the first three or four appointments the doctor seeing the patient does the work ordered. Incidentally, the work done on each patient is recorded on his worksheet at the day's end and, during the course of the day, the assistant keeps a list of all patients and work done by each doctor.

Once most of the bands have been placed the original work ordered by one man is not always done. If the patient comes to me with the order to change the upper arch, yet I feel the lower is the one I'd like to change, reference is made to the worksheet noting the last recording as to what was done and by which doctor. It simply means calling the operator concerned, having a discusson to determine what his intent was or explaining why I prefer doing this arch instead. This, and I cannot overemphasize enough, has been one of the most valuable teaching methods we've uncovered. Invariably, one of us would have forgotten some one little thing that was picked up by another. This stimulates one's thinking and, of course, steers the treatment in the right direction at the greatest possible speed. The code we use to determine which doctor recorded the work involves colored ink. Each doctor has a different color, so by noting the color of the last recorded work on the patient's worksheet, it informs us which one ordered this particular procedure with which you disagree. Again, a marvelous built-in study club. Never in any of our individual practices did we take anywhere near the number of study models and progress headplates as we now do. Whenever any question comes up as to whether or not enough anchorage has been established, whether or not to retract the anterior teeth more or not, etc., these progress records are ordered and taken—again with the aid of the technician. Then further study by all three doctors and revamping of treatment plan is ordered if indicated.

Once the case has reached the stage of retention, the bands are removed after having been checked by at least two of the doctors, one of them being the one originally contacted by the patient. Impressions are taken for models on which to construct the retainers and final records made. This includes models, full mouth and cephalometric x-rays and the photographs. Retention appointments are handled as were the full treatment appointments, by any one of the three men.

The tooth brushing area, as was earlier stated, houses all brushes for the patients under treatment. These are given to the patient once the first archwire has been tied to place. They are instructed by the assistant as to the method of tooth brushing we prefer

while they are wearing the appliances. A pigeon hole is assigned to them and a brush placed within a plastic container is given to them. The routine has become established so that after the patient has informed the receptionist of his presence, he immediately goes to the tooth brush area and "gets them clean." Then he seats himself in the reception room and awaits his turn. If the teeth are unclean when he is seen by the doctor, a follow-up is made on this youngster's oral hygiene. We can determine if the patient understood the method explained, whether or not he is conscientious, etc. It certainly reduces the probability of food remaining attached to the appliances throughout treatment. Beyond question we are sure the teeth are properly brushed at least once every two or three weeks.

Personnel

The team that has made this orthodontic case progress as smoothly as possible is made up of three orthodontists, their dental assistants, the hygienist, x-ray technician, two laboratory technicians, a receptionist, and a clerk/bookkeeper. One other person is employed who is a "jack-of-all-trades." She is available throughout the office and can double in any of the capacities of the other employees. Anyone not available for the day's work has only to report by phone and the "floater" steps in. I might add that this person is a definite asset in the office. Gibbens[2] concurs by pointing out that "efficient auxiliary personnel are necessary adjuncts to the effective conduct of an orthodontic practice." This factor has also been recognized by the American College of Dentists whose Committee on Socio-Economics[6] has itemized as a problem for future attention and planning: "Improved dental practice administration methods should be promoted whereby dentists would make more use of auxiliary personnel."

The most recent addition to our staff has been a male office manager, who has been assigned the duty of correlating and maintaining a smooth organization functioning to capacity. Of course, this includes supervision of the personnel, the physical plant, supplies, etc. With our many employees, the personnel problems are by no means small tasks. In other words, he assumes the headaches of the business management of the practice—the doctors perform the orthodontics.

Certainly, any operation involving this many different people has many problems arising from time to time. As they do present themselves they are tackled, many times by the trial-and-error method, until a workable solution for our particular practice has been reached.

Disadvantages

In addition to these ever-present problems, let us reflect a moment on some of the distant disadvantages of a group practice:

1) Liability—not only does this include professional or on-premises but likewise extends to the personal life of each member. Automobile liability, property damage, etc. become a common concern.
2) Less personal contact with the individual patient. It could happen that you would see one particular patient only once in six months.
3) Especially easy to overexpand the patient load. With three men drawing for one practice, care must be exercised in the number of cases undertaken.
4) More off-duty hours consumed with staff meetings; conferences of the three doctors both with themselves and with the business manager.
5) Yielding to the majority regard-

ing policies of office management you may not especially like.

Summary and Conclusion

To counterbalance these disadvantages, let me recall in summary some of the advantages, much more weighty than the disadvantages to us in our group practice.

1) Vacations, illness, retirement, death are accounted for.
2) Increased income.*
3) Built-in study club, three heads instead of one.
4) Consultation on all cases.
5) More efficiency with aid of auxiliary personnel. A larger volume can be enjoyed without jeopardizing treatment.
6) Good will has become real — a tangible, salable asset.
7) Ability to keep abreast of any new orthodontic findings for all meetings can be attended by at least one of the three members.
8) Buying power:
   A) Quantity lots regarding supplies.
   B) Larger office space than could be afforded on an individual basis.
   C) Better utilization of auxiliary help.
9) Easy addition of another orthodontist to staff with this type practice.
10) Practice constantly growing. Good will doesn't dwindle with age and/or drive.

In concluson, a group orthodontic practice has a very important role to play in our modern-day society. It offers many challenges which take firm courage of your convictions to overcome, but it also offers the exhilarating reward of complete personal satisfaction. Working in unison as a team has led us to our common goal — professional service to our community, security for ourselves and our families, and peace of mind!

1033 S. W. Yamhill

*The 1954 Survey of Dental Practice conducted by the Bureau of Economic Research and Statistics of the American Dental Association reported that the solo practitioner had a mean net income of $10,725. The dentist who shared part of the costs of practice through various arrangements reported $11,039. The dentist who practiced in a complete partnership reported $14,876.

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An Improved Soldering Technic

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The history of the early form of soldering dates back as far as 2500 B.C. when records disclose that silver was probably first mined from the islands in the Aegean Sea. As the years passed, methods of working gold and silver became a separate art; much of it was secret and personal ornaments, utensils, vases, and decorative objects made of gold or silver with their various alloys became known as silversmiths' or goldsmiths' work.

The mechanical phase of dentistry would be sadly in want were it not for the ability of the operator to perform many acts of soldering which closely parallel the work of the goldsmith's and the silversmith's.

The technic of soldering, as taught over the past years to orthodontists, has been to fuse gold wire to gold bands by either silver or gold solder melted by fine flame from a gas torch. This is the universally accepted method and in good soldering it has always resulted in a firm well-bonded joint.

With the introduction of chrome alloys to orthodontics in the 1930's, high fusing soldering became an art all its own and, frequently, even the best chrome alloy technicians were forced to admit defeat in some phases of their soldering. Either the wire or the band material became annealed or the wire would corrode and break at the soldered joint.

This lack of a secure soldering method impeded the growth of chrome technic for many years until men who advocated the use of chrome, in an effort to overcome this deficiency, turned to lower fusing solders known as eutectic solder. This type of solder needs very little heat from a torch and for most technic work it has proven to be quite satisfactory; unfortunately, this low fusing solder does not always maintain its luster and requires considerable bulk for its strength.

Technicians have long been hopeful that we could find a simple soldering method for the higher fusing gold solders which would not discolor and at the same time afford a stronger bond between two pieces of chrome alloy. Partial success was achieved by good technicians in this direction when they used the high heat developed from an oxygen torch, but for the average operator this method is still slow and risky when the arch temper can suddenly be lost with one careless maneuver of the flame.

Chrome alloy soldering involves a different principle of adhesion from that of gold soldering. This metal, unlike gold, apparently does not unite with the solder to become an integral part of the chrome ore, but rather it fuses to the outer surface of the metal and its action resembles to a great extent the soldering process known as brazing.

If chrome alloy is heated by torch in an attempt to draw the high fusing solder to it with heat, there is a wall of oxide that develops on the metal which inhibits the union of the solder to the chrome ore and, even when the operator specifically attempts to heat the solder where it is placed on the metal, the radiating heat from the torch tends to partially anneal the wires thus

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causing oxidation. This is the prime objection to the use of the torch.

This paper is not written with the intent of settling the argument of which is better, gold technic or chrome technic, but rather to introduce a fast practical application of an orthodontic soldering technic for both gold and chrome.

When one who has been accustomed to fine technic work by torch flame for many years is suddenly confronted with a method of soldering that is nearly foolproof there is at first a feeling of complete disbelief; then the realization comes that, as we progress in all walks of life, some of our artistic skills must make room for the more advanced and practical applications just as the conventional gear shift, in most instances, has been replaced by the automatic gear shift in the automobile.

In 1952 one of the major orthodontic supply houses placed a welding and carbon solder machine on the market. This machine has variable heat controls for both the weld unit and the carbon copper electrodes which are separately connected with extension cords. At approximately the same time another major company, after experimenting for several years with the carbon soldering unit, finally discontinued any further tests because of the tedious job of keeping the electrodes clean. From the very beginning the carbon tip on all the manufacturers' machines tended to clog with the heated flux and frequently failed to make electrical contact at critical moments; therefore this added unit did not meet with the approval of most orthodontists. Experimenting with the Rocky Mountain model (in production since 1953) gradually led the author to find and develop a more positive soldering technic for chrome alloys that is relatively simple and fast.

The use of this technic will open the door for new and improved applications in both chrome alloy and gold; many soldering applications heretofore employed exclusively to gold may now be applied to the chrome alloys.

To prepare for soldering, a 506 Rocky Mountain welder is used with the adapting cables that plug into the two outside annealing inserts. One of the cords has a special alligator clip attached to its terminus while the other cord ends in a sharply pointed carbon tip. The switch is turned to heat control No. 4 for nearly all wire soldering. Number 5 must never be used for soldering. With this machine the operator is at liberty to use either the lock nut to hold the current on or the foot switch which permits a remote control activation of the electrical circuit. The clip is used for a two fold purpose; (1) to conduct the current and (2) to act as a jig which grips the material to be soldered. A high fusing flux (R.M. Tru-chrome) is brushed into the welded joint and a small piece of .013 S. S. White 14K 490 gold solder (melting 1365-1435°F) cut in triangles approximately 1.5 mm on a side is placed directly over the weld area. The solder may be cut in different sizes and shapes according to the need. The actual soldering is almost instantaneous. First the carbon tip anode is dipped in water to insure electrical contact with the piece of solder; the carbon is placed directly on the small piece of solder, and to complete the operation the foot control is depressed for approximately four-tenths of a second. (Longer for .030 wire or larger and shorter for wire below .014 dimension). The operator will very quickly become adept with this technic by watching the solder melt.

Certain characteristics of direct current discovered in 1881 make this soldering method quite simple because it

was found that the current literally flows downhill from the anode to cathode allowing the carbon tip to heat bright red while the opposite pole hardly becomes warm. The clip must always be placed within one mm of the working area and even closer for very small .010 wires.*

For special type soldering, .012 dead soft wire is lightly welded to two separate pieces of chrome alloy. These pieces of chrome can be placed end to end and joined by the third wire, or the small wire can be used to unite a "T" joint thus avoiding overlapping. An important use of this application is in direct work (Fig. 1) for the alignment of larger wires as in cuspid to cuspid retention, in placement of a fixed lingual bar to molar bands or in repair of broken wires. This work can be quickly measured and withdrawn from the mouth without distortion and the cathode clip placed on either band "A" or wire "D" to form the electrical circuit. Soldering can be performed merely by following the procedure of (1) fluxing, (2) placing the solder and (3) completing the electrical circuit with the carbon tip touching the solder. The solder must not be placed beyond the bridge of .012 soft wire, or this will melt when the current is turned on.

To avoid flux contamination in all the procedures the hot carbon tip is plunged into water immediately after the solder has melted, thus washing away the remnants of the flux.

Occasionally when the carbon fails to make contact on the solder, it should be quickly preheated by placing it on top of the alligator clip (switch on) and shorting with the electric current. A moistened carbon tip is desirable for all soldering.

Fig. 1. Soldering cuspid to cuspid. A, band; B, solder; C, carbon tip; D. lingual wire; E, alligator clip.

This technic for orthodontics in soldering chrome wires or chrome to gold can best be performed when employing either of the following forms of welding: lap joints .010 up to .052 wire or butt joints — any size wire joined by flattened .012 bridge wire (dead soft).

The major uses in orthodontics of this type of soldering are: soldering of prewelded chrome wires or springs of any size (Fig. 2) directly to the archwire or band material of either gold or chrome, reinforcement of band

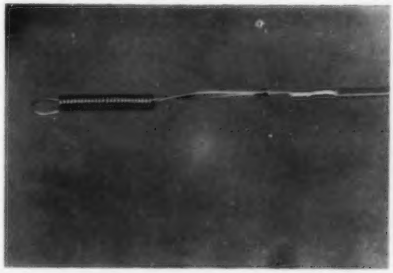

Fig. 2. .010 closing loop spring soldered to .020 square wire.

*A special coil and switch must be ordered with the 506 welder to do .010 tacking. The Unitec model "Unimatic Spotwelder model 1000" can tack weld if the charge is taken out of the transformer by turning the switch off and pressing the button, then quickly flipping the switch on, and then off. This produces a very light electrical charge. The same action can be obtained on "Lo Weld" in the RM Spot Welder No. 650.

material surfaces or ends of wire and repairing wires broken near acrylic on retainers (heat will not melt acrylic where procedures are correctly followed).

It is the author's belief that carbon tip soldering will be greatly enhanced if further experiments are conducted with various sizes of carbon tips and if a research program is developed which will offer an improved solder for this technic.

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Book Reviews

CLINICAL CEPHALOMETRY

Viken Sassouni, Philadelphia, 1959. 248 pages. Illustrated.

THE FACE: IN FIVE DIMENSIONS

Viken Sassouni. Growth Center Publication, Philadelphia, 1960. 317 pages. Illustrated, including acetate transparencies of tracings.

These companion volumes represent a critical review of the literature (a mammoth task) and attempt a sharper focus on clinical appraisal via cephalometric analysis. They overwhelm a reviewer whose orthodontic training and experience have been totally oriented to private practice. With this apologia it may not be amiss to suggest that Dr. Sassouni has indeed covered too much ground. Too much for the average clinician as well as for himself; so great is his scope, sheer lack of space has required a "once-over-lightly" approach.

The two volumes are outgrowths of Sassouni's teaching and research activities at the Philadelphia Center For Research In Child Growth, under the direction of W. M. Krogman, and stem directly from their survey of world cephalometric literature compiled in the "Syllabus in Roentgenographic Cephalometry" published in 1957. Primarily intended for orthodontic teaching purposes it is the author's hope that both the clinician and researcher will be stimulated.

Lest the enormous detail cause the average orthodontist to shy off from an earnest study, he may be encouraged by the following from the last page of concluding remarks in "Clinical Cephalometry":

> "Its (Sassouni's archeal analysis) clinical significance and application for treatment planning depend, however, on the general background of the specialist".

The "raison d'etre" for Dr. Sassouni's contribution is found on page fifty-six of "Clinical Cephalometry". In the "Syllabus" he evaluated forty-five different types of analyses only to find a "vicious circle" confining them. No attempt at a solution for the contradictions was attempted; his hope was that others would be stimulated to seek it. This not having materialized he here attempts "on the basis of evidence from the literature and from personal investigation to give the clinician a temporary working tool".

"Clinical Cephalometry" contains four sections: I, General Background; II, Orthodontic Records; III, Cephalometric Technique; IV, Diagnostic Analysis. There is also an Appendix containing the author's project, undertaken for the Quartermaster Research and Development Command, United States Army, on a method of identification of war dead by means of roentgenographic cephalometry. This report could well have been omitted as not germane.

Parts I and III, general background and cephalometric technique, seem less well organized than parts II and IV. The general background material in Part I is available from other texts.

Part III deals with cephalometric technique — possible errors, selection of landmarks ("the best are easily and accurately located and represent - - - a significant point of a facial structure") and they are defined and illustrated. Here too, Sassouni explains his preference for the "optic plane", for orienting lateral film tracings on the printed page over the traditional Frankfort Horizontal Plane. The discussion of superimposition of tracings of serial

films is not handled comprehensively but a method of orienting the P - A and lateral films is described.

Part II, orthodontic records, is a comprehensive review of the possibilities in this area. Most clinicians will regard as impractical the recommendation that the parents and siblings of each orthodontic patient be not only examined but records taken on all. Nevertheless, and recognizing that much of this section is also available elsewhere, Sassouni's suggestions would more clearly evaluate the problem at hand. All details are organized on a printed form suitable for office use (p.23).

The fourth section of "Clinical Cephalometry", Diagnostic Analysis, describes, classifies and criticizes the various analyses. It is Sassouni's opinion that these analyses have, in general, two errors: 1) the use of only a single base line or plane of reference and 2) adherence to profile assessment. He shows how only one such base line, or plane may be subject to individual variation; then the entire analysis is invalid. For the second most frequent error in the available analyses, assessment of the profile, he seems to be on less solid ground. Most clinical problems are in fact problems of anteroposterior imbalance, but there is no denying that less attention has been given to transverse and vertical proportions and still less to correlation of the three dimensions.

The archeal analysis is presented as a means of overcoming these disadvantages. A single plane of reference is replaced, in the tracing from the lateral film, by four planes converging posteriorly at a point or, more often, at "an area of convergence", the center "O". (The four planes: supraorbital, palatal, occlusal and mandibular). From the center, or area, "O", the archeal analysis constructs four arcs, intersecting the four base planes, to the anterior, middle and posterior facial areas. These arcs provide a frame of reference to evaluate each patient's individual symmetry and proportions without recourse to measurements to be compared with a table of norms. Sassouni considers that "clinically, it shows the *minimum* required to correct deviations according to that facial type, rather than according to averages". It may be remarked that selecting the "area of convergence" of the four base planes would seem to leave much to individual judgment.

Clinical Cephalometry concludes with discussion of correlative analyses (Bjork, Bushra, et al.) which Sassouni considers of greater value than others since they recognize variations of dentofacial structures which may be normal even if undesirable.

Having applied the archeal analysis to "a couple of thousand cases", Sassouni considers it a simple, readily applied method but admits to needed refinement.

It is unfortunate that the material on the archeal analysis is not organized in a single chapter or section in place of being sandwiched in at multiple points.

"The Face: In Five Dimensions" is essentially the application of the theories enunciated in "Clinical Cephalometry" to a group of eighty-six individuals: normal occlusions, Class II, Class III, biprotrusion open-bite and biretrusion closed bite. This is a large order! Yet it is approached by a threefold assessment: 1) measurements in depth, height and breadth compared with averages having a standard deviation of ± one; 2) compared with cephalometric standard tracings; 3) assessment via the archeal analysis.

In Krogman's introductory outline of "The Face", the above is described as the core of the book. This is accurate and still there are nine other sections. The first four — the *Atlas*,

(the skull), the *Analysis* (three-fold assessment outline above), the *Standards* (geometrically derived averages of normal occlusion, as described by Broadbent, in the form of tracings of complementary lateral and P - A films of whites at four, eight, twelve and sixteen years and adulthood depicted on acetate transparencies, plus Negro and Chinese), and the *Racial Comparisons* — are better organized than the five parts following the case histories but suffer from lack of detail and meager information.

These, the last five sections, are titled *Facial Growth* (time, the fourth dimension), *Heredity* (the fifth dimension), *Pathology, Comparative Anatomy* and *Orthodontic Treatment*. These sections seem brief to the point of being ineffective. Part 6, Facial Growth, further elucidates the archeal analysis and contains Sassouni's comparisons with the standards of the Bolton study, of Bjork and of Moorrees.

Over-all, these two volumes bring together an enormous amount of material not otherwise readily available. It is unfortunate they are marred, particularly "The Face", by innumerable typographical errors and by failure to provide fundamental information in place of the author's opinions.

M. R. Newcomb

The Dentition of the Growing Child

Coenraad F. A. Moorrees, 245 pages with 68 figures. Harvard University Press, Cambridge, Massachusetts, 1959.

The material for this book was obtained from the plaster casts of one hundred eighty-four children, most of whom were participants in the Harvard Growth Study and the remaining youngsters from the Stucklen group of Wilmington, Delaware. Each child was observed over a period of twelve to fifteen years covering the transition from the primary to the secondary dentition.

Unlike some investigators, Moorrees does not dismiss lightly the limitations of his data. At the final examination, usually at age eighteen, one-third of the entire group had a normal anatomical occlusion with a full complement of teeth, exclusive of third molars. Twenty-eight children had pronounced malocclusions, while extraction of permanent teeth characterized many individuals. Despite these and other limitations, which he presents, the author believes an analysis of the material is justified for it is a comprehensive series. Furthermore, it would take at least another fifteen years to accumulate data more satisfactory according to present day standards providing that all the risks inherent in such a longitudinal project could be eliminated.

Through the use of individual composite graphs the changes in tooth positions and relations are charted.

A biometric analysis of the data from youngsters with *normal* occlusions comprises a large portion of the book. It is stated that a considerable range of variation exists between the combined mesiodistal crown diameters of the deciduous teeth and of the permanent teeth; despite the fact that, on the average, the permanent exceeds the deciduous, the combined crown diameters of the former can be smaller or larger than their deciduous predecessors, or even the same size.

Measurements from the casts corroborate Baume's conclusion that the average amount of interdental space in the deciduous dentition does not increase after three years of age.

Recognizing that *prediction* of future development is the basic aim of growth studies, Moorrees feels his data show definitely that the pattern of den-

tal growth is to a large extent peculiar for the individual and that it may deviate, sometimes to a marked degree, from that of the group.

Several case reports are given to illustrate the use of factual information, gathered longitudinally, which is helpful in attempting to forecast a probable course of individual dental development. The use of the data in orthodontic prognosis is discussed in general terms as are clinical applications of the research findings.

There is an Appendix of thirty-two tables containing the tabulation of the original data for arch length, arch breadth and available space.

To the reviewer, one fundamental conclusion can be reached from this book: the dentition of the growing child can only be studied by really studying the dentition of the child; no other individual or average can take his place.

Arthur B. Lewis

The Angle Orthodontist

A magazine established by the co-workers of Edward H. Angle, in his memory . . .

Editor: Arthur B. Lewis.

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Line drawings should be prepared in India ink on white stock; the width of lines and the size of lettering should take into account the fact that most illustrations are reduced in size in the engraving process. Photographs should be sharp, glossy prints of adequate size, *unmounted and kept separate from the text.* At the discretion of the editor, illustrations will be reproduced either as single column cuts of approximately 2¼ inches in width, or as double column cuts of 4¾ inches in width. The height of the cut may vary, but contributors should keep in mind that proportionate reduction or enlargement of illustrations affects all dimensions, and that arrangement of material should be such that awkward proportions are avoided and no loss of clarity results.

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